

4.6 ZAIRE

Introduction

Zaire is the third largest country in Africa, after Sudan and Algeria, and the fourth most populous. With an area of 2 345 410 km², and 33 944 000 people (1983), it has the comparatively high population density of 13.6 persons/km². It lies across the equator, reaching 13°25'S in the southeastern extremity, and 5°23'N in a bend of the Bomu River on the northern frontier. It is bounded by Angola in the southwest, Zambia in the south, Tanzania, Burundi, Rwanda and Uganda in the east, Sudan and The Central African Republic in the north, and Congo and the Cabinda enclave of Angola in the west. It has an Atlantic coastline of 40 km at the mouth of the Zaire River, between Angola and Cabinda, and extends some 2099 km from east to west and 2062 km from north to south.

The eastern border is mountainous, all the way from Zambia to Uganda. The mountains of Shaba (Katanga) Province in the extreme SE rise to 1889 m asl at Mt. Kiapulka, and along the western side of Lake Tanganyika the Mungila Mountains rise to more than 2000 m in several places. Beginning at the northern end of this lake the Mitumba Mountains run north to Uganda, reaching over 3000 m asl near Uvira (3°24'S/29°05'E) and along the western shore of Lake Kivu, while to the north of this lake they reach 4507 m asl at Mt. Karisimbi (1°31'S/29°27'E) and 3645 m asl at Mt. Sabinyo (1°23'S/ 29°36'E). This same chain again rises above 3000 m asl near Lubero (0°16'S/29°45' and 0°10'S/29°40'E) and to a maximum elevation of 5110 m asl at Mt. Stanley (0°24'N/ 29°55'E). Mt. Aburo (2°01'N/30°50'E), at 2437 m asl, is the highest point at the northern end of the chain. Along this border, which follows the western rim of the Great Rift Valley, there are large areas of very high land. In the vicinity of Mt. Stanley alone, 35 000 ha rise above 3000 m asl, and along the entire mountain chain, a total of more than 4 275 000 ha lies above 1500 m asl. The southern and northern borders of Zaire are situated on elevated plateaux which slope gently towards the interior, but with numerous scarps so that almost all rivers flowing off the plateaux to the central depression traverse several waterfalls or rapids. The southern plateau reaches heights of 1500 m asl on the Zambian border, but mostly lies between 500 and 1100 m asl, while the northern plateau is 500-700 m asl.

A lake occupied the central depression of the Zaire Basin during the Pliocene, and the present effluent stream, the lower Zaire River, arose

when a coastal river cut back to capture the lake water before the end of that epoch. The lake was thus drained, but a large swampy and seasonally flooded area now occupies the western, lowest, part of the basin. Here Lakes Tumba and Mai Ndombe may be regarded as remnants of the huge Pliocene lake. Although during the dry phases of the Pleistocene the vegetation of the Zaire Basin was drastically altered, the river system has persisted with comparatively little change throughout the Quarternary, and indeed the entire Zaire Basin has been characterised by environmental stability over very long time periods, which in concert with the wide range of habitats it provides has favoured speciation. Thus 669 species of fish have been described from the river system, of which 558 are endemic, and it may well be that before zoological exploration is complete, over a 1000 fish species will be identified. Almost equally remarkable are the 22 different freshwater crabs (Potamonidae) so far described.

More than 90% of Zaire drains to the Zaire River. The two principal Zairean headwater streams of this river, the Lualaba and Lufira, rise in Shaba in the southeast, close to the Zambian border at the points 11°52'S/26°25'E (Lualaba) and 11°52'S/26°52'E (Lufira). The Zaire River is called the Lualaba in its upper course, and at first flows north, then west and south, crossing the equator twice in a great arc as it traverses a vast swampy basin over 1050 km from east to west and up to 850 km from north to south. Here, and extending into the neighbouring state of Congo, over 65 000 000 ha of very flat lowland lies between the 300 and 500 m contours in an ancient depression. This depression was invaded by the sea during the Mesozoic, subsequent to which its basin-like nature has been emphasized by persistent subsidence at the centre and compensatory uplifting of the margins, so that now, at the western extremity, the Zaire River traverses the low rim on its way to the sea. It flows through a gorge some 360 km long and containing no less than 32 rapids, between Kinshasa (4°18'S/15°18'E) and Matadi (5°50'S/15°52'E), descending in this section, from 307 m to 3 m asl. From the last rapids to the Atlantic Ocean is a distance of about 150 km, and the river is tidal for the last 95 km. Even below Matadi it flows through narrow gorges, and where it enters the ocean its bed occupies a deeply graven submarine canyon. Only in the northeast is there a part of Zaire which does not drain to the Zaire River. Here, on the border with Uganda, some short streams enter the Nile Basin via Lake Edward, the Semliki River and Lake Albert.

Climate

Rain falls over the central basin throughout the year, but is more seasonal on the borders. A broad per-humid belt extends inland along the equator

from the Atlantic coast, over Gabon, across Congo and into Zaire. Throughout this belt, which reaches 3°40'S, but only 1°N, mean annual rainfall exceeds 1800 mm. In its central section a vast area around Boende (0°15'S/20°51'E) receives more than 2000 mm. In the east another vast area, mainly south of the equator, extending into the basin from the mountains of Rwanda and Burundi, also receives mean annual falls in excess of 2000 mm, while the western slopes of the mountains near Bukavu (2°30'S/28°50'E) receive up to 2800 mm. Mean annual rainfall at Kisangani (= Stanleyville, 0°32'N/25°14'E) at the eastern end of the Zaire Basin, 415 m asl, and just north of the equatorial rainbelt proper, is 1703 mm. October is the wettest month with falls of over 200 mm, while December, January and February are the driest months. Mean monthly rainfall at Kisangani in January is 50 mm. However, 110 km to the south, Ubundu (0°24'S/25°30'E) receives over 1800 mm/yr, and 215 km SE, Lubutu (0°45'S/26°37'E) receives over 2000 mm with no distinctly dry months.

There is cloud cover over the equatorial region for much of the year and incident solar radiation is lowest there. It is less than 130 Kcal/cm²/yr in a zone extending from the coast inland over the western part of the central basin, including Kinshasa, Lake Mai Ndombe and the entire courses of the Lukenie and Lokoro Rivers. At the far eastern side of the basin Lubutu receives 140 Kcal/cm²/yr and the mountainous border with Rwanda and Burundi about 150 Kcal/cm²/yr. Radiation increases progressively away from this equatorial cloudy zone towards the borders, north and south. Thus at the far end of the basin Kisangani and Kibombo (3°58'S/25°54'E) both have mean annual receipts of 145 Kcal/cm². Along the northern border Bangui (4°23'N/18°37'E), Mobayi-Mbongo (4°21'N/21°10'E), Bondo (3°47'N/23°50'E) and Bambesa (3°25'N/25°43'E) receive 165-170 Kcal/cm²/yr. In the southeast the central part of Lake Tanganyika, and Lake Mweru, both have mean annual receipts of 170 Kcal/cm², while farther west the Upemba Lakes (8°37'S/26°24'E) receive 166 Kcal/cm²/yr, and the southern central border with Angola 145-155 Kcal/cm²/yr.

Sunshine follows a slightly different pattern. The coast receives 1700 hours/yr, decreasing up the Zaire Estuary to 1300 hours/yr at Matadi. From here passing inland, sunshine increases to 1650 hours at Kinshasa and 2000 hours/yr at the western end of the interior basin. Most of the basin and the northern borderlands receive this same level of sunshine, i.e. 5.6 hours/day, but there is an increase southwards to maximum levels of 2600 hours/yr at Lakes Mweru and Upemba, while the rest of the southern borderlands receive 2300-2500 hours/yr. Relative humidity follows a similar pattern to insolation and precipitation, with a large central area astride the equator

having a mean annual RH of over 85 %, decreasing to 80% along the northern border and 70-75% on the eastern and southern borders. Only the Shaba Plateau in the extreme SE experiences mean annual RH values below 70%.

As might be expected from the foregoing, mean annual temperatures vary little over the central parts of Zaire. Most of the country experiences a mean annual temperature of 24°C, with an area south of the equator, centred on Lake Mai Ndombe, having a mean figure of 25°C. The coastal sector is cooler, c. 23°C, the Shaba Plateau cooler still, with mean temperatures of 19-20°C, while along the eastern border mean temperatures vary with site, falling below 15°C in the mountains locally. Mean daily maxima are 30°C over most of the country, falling below this in the mountains and on the Shaba Plateau. Mean daily minima are 21°C around Lake Mai Ndombe, 20°C in the rest of the western basin, 19°C in the eastern half of the basin, 14-15°C on the Shaba Plateau and 12-15°C along the eastern border. However, frosts occur on the highest mountains where precipitation may be in the form of snow. The snowline is about 4500 m asl and there is a permanent snowfield at Mt. Stanley.

Wind velocities are very light over the entire country. Estimated at 2 m above ground, mean annual wind velocities are below 3 km/hour in the western part of the central basin, and 3-4 km/hour in the eastern half. Winds are higher on the borders, with mean annual velocities of 4 km/hour along the northern border and 4-5 km/hour in the south. Along the eastern border mean annual velocities exceed 6 km/hour. Maximum wind speeds recorded at various stations include 28.3 km/hour at Kinshasa (310 m asl), 25.8 km/hour at Bambesa (621 m asl), 28.5 km/hour at Simana (09°37'S/27°01'E - 852 m asl) and 24 km/hour at Rubona (02°29'S/29°46'E - 1706 m asp).

Wetlands

A number of large lakes lie along the eastern border of Zaire in the trough of the Great Rift Valley, which are, from south to north, Lakes Tanganyika, Kivu, Edward and Albert. Hard against the eastern border between Lakes Kivu and Tanganyika, the valley of the Ruzizi River contains extensive wetlands, as does the plain to the south of Lake Edward, and the valley of the Semliki River draining Lake Edward to Lake Albert. Wet swampy plateaux occur at intervals all along the high watershed immediately to the west of the lakes of the Rift Valley system. In the extreme southeast, part of Lake Mweru is situated in Zaire, and there is an extensive floodplain along the Luapula River to the south of this lake, where that river forms the border with Zambia. There are also wetlands associated with the mountains of

the Shaba Plateau to the west. Here are the two principal reservoirs of Zaire, Lake Tshangalele, on the Lufira River, over 1000 m asl, and Lake Delcommune, where the Lualaba River is dammed. Some 20 substantial lakes occur farther downstream on the Lualaba where it traverses the Kamolondo Depression. Extensive swamps and floodplain systems occur around Lake Tshangalele and the Upemba Lakes.

Other wetlands occur along the upper courses of the large rivers flowing northwards across the southern plateau in Kasai Province, and there are innumerable large bogs and swamps in the headwaters of their tributaries. For example, in the vicinity of Sandoa (9°41'S/22°56'E), swamps are well developed along the Lulua and its tributaries, and wetlands comprise 20-45 % of the land surface over very large areas. To the south, in the vicinity of Dibaya (6°31'S/22°57'E), a vast block of land exceeding 4000 km², is covered by *Encephalartos poggei* entangled by thickets of the spiny twiner *Smilax kraussiana*. Here, countless gullies containing periodically inundated gallery forests are tributary either to the Lulua River, or the Miao and Lukula Rivers in the east. From the air the galleries on the dendritic drainage system give the landscape the look of alveoli in a lung. Throughout this region the bed of the Lulua is broad and sandy, 400-650 m wide, with numerous little islands.

Having descended from the Shaba Plateau, the Lualaba flows comparatively slowly for several hundred kilometres, with accompanying riverine forest and some swamps, before descending a waterfall and reaching the 500 m contour at Kasongo (4°32'S/26°33'E), and a rapids section and a further waterfall above Kindu (3°00'S/25°56'E). North of here the river becomes much wider, 2-3 km in places, and descends the 7 cataracts of Boyoma or Stanley Falls (0°18'N/25°29'E) before its middle course is deemed to begin and it becomes known as the Zaire River.

In its middle course the Zaire River varies in width between 3-15 km and in depth between 3-10 m, and loses only 115 m in altitude over a river distance of 1740 km between Boyoma Falls and Malebo Pool (4°11'S/15°35'E), therefore having a mean gradient of 1:15 000. Over 1500 km of this stretch, between Kisangani and Tshumbiri (2°36'S/16°16'E), the river itself provides some 1 400 000 ha of very slow flowing open water which has many of the characteristics of a lacustrine, rather than a riverine water body. For much of this distance it flows in a shallow bed with pronounced levees, around almost continuous chains of islands and sand banks, through virtually unbroken primary rain forest. The two major tributaries, the Oubangui (Ubangi) and Kasai (Casai), which join the river towards the western side of the depression, provide a further 680 000 ha of open water and similar riparian environments. For distances of 1000 km and 700 km respectively, these two rivers attain mean widths of 4 km and are also island studded, although the Kasai is only

markedly so in its lower reaches. Many of the islands are partially or fully inundated at periods of high water. Behind the levees, permanent and periodically inundated swamp forests extend for distances of up to 35 km on either side of the rivers on continuous alluvial tracts. The Oubangui joins the Zaire River opposite Lake Tumba, almost on the equator, where land is lowest and swamps most extensive. The total area of swamp forest in the central Zaire Basin is difficult to assess, because virtually every river, large and small, overflows its banks periodically and is accompanied by a tract of poorly drained alluvium which supports wetland vegetation. There are at least 12 000 000 ha of permanently or seasonally inundated forest in the Zairean part of the Zaire River Basin, with another 6 500 000 ha on the west bank of the Oubangui in Congo, and it is quite possible that the former figure is a substantial underestimate.

All the tributaries of the Zaire River are perennial, and flow in the river is fairly constant throughout the year. Mean annual flow rate at Kisangani is 7000 m³/sec, but 41 300 m³/sec at Kinshasa, second in volume only to the Amazon. A maximum discharge rate of over 65 000 m³/sec was recorded in 1908, and over 75 000 m³/sec in 1961, while the record low discharge rate was 21 422 m³/sec in the exceptionally dry year of 1905. Although the equatorial rain belt moves from north to south across the equator, and rain is seasonal over the peripheral catchments, the rainy season in the north coincides with the dry season in the south and *vice versa*; thus heavy rain in the north tends to compensate for light rain in the south and river flow does not change dramatically over the course of a year. Nevertheless, levels in the watercourses of the flat central basin normally exhibit two maxima and two minima each year. The main peak at both Lake Tumba and Malebo Pool is in December-January, coincident with the austral summer rains, followed by a minimum in March-April. A second peak occurs in May-June, coinciding with the onset of the boreal summer rains, while the lowest levels occur in July-September. During the high water periods vast areas of land adjacent to rivers in the central basin are flooded. These areas drain during the low water periods, which occur twice a year, but the main rivers do not contract significantly within their beds.

Downstream at Tshumbiri the river enters a 220 km stretch known as the Chenal, where it is confined by low hills to a narrow channel, 900-1600 m wide, and where swamp forest is largely absent. In this section the river deepens to 25-30 m, and the current becomes more swift, and it is here that the Kasai enters on the south bank. The Chenal ends in Malebo Pool, formerly known as Stanley Pool, an almost circular lacustrine expanse of about 52 000 ha containing a large central island.

Other wetlands occur in Bas-Zaire, the province between Kinshasa and the

Atlantic Ocean, which encompasses Malebo Pool and the lower course of the Zaire River and several of its tributaries. The wetlands include reed and papyrus swamps around Malebo Pool and in the valleys of the Luina and Lunionzo Rivers, peat bogs and grass swamps in the valley of the Inkisi River, and periodically inundated savannas. The many rivers of the region all support forests subject to varying degrees of inundation. The periodically inundated sandy banks of rivers, including the Zaire River, support riparian forests along tranquil river stretches, with variant types along unstable and stable banks in the cataract regions. *Pandanus* forest occurs along some rivers, even colonising parts of the river bed, e.g. that of some tributary streams in the basin of the Inkisi River. Immediately behind levees on many streams there are extensive riverine swamp forests, subject to alternate flooding and exposure, and dominated by *Dracaena* and *Pseudospondias*. Other forests, comprising a different spectrum of species depending upon edaphic conditions but all subject to permanent inundation, are found around Malebo Pool, in depressions in the large valley of the Nsele River and in choked valleys on schisto-calcareous soils in the Songolo region. Such forests also have a scattered occurrence in small depressions throughout Bas-Zaire.

Other seasonal wetlands, reed, sedge and grass swamps, flooded savannas, and riparian and riverine forests, occur on the plateau in the north of the country between the Oubangui and Zaire Rivers.

Flora & Fauna

Zaire is greater in area than the other five countries of the region combined, and judged by mean annual precipitation intensity, which is close to 1700 mm, it is among the wettest of countries in Africa. It contains more wetland than any other African country and presents a wider range of edaphic, climatic and topographical conditions than the other countries of the region, except perhaps Cameroon. In consequence there is a greater floristic and faunistic variation within each wetland type than is observed in the other countries, apart from that which arises simply from differing inundation regimes. In consequence, the floras and faunas of the wetlands and lakes are described separately for each of the areas or systems discussed below.

List of Wetlands Described

1. Wetlands of Bas-Zaire
2. Wetlands of South Bandundu, Kasai Occidental & Oriental
3. Wetlands of Shaba Province
 - (a) The High Plateau Country

- (b) Lake Mweru
 - (c) The Luapula Floodplain
 - (d) Lake Tshangalele & the Lufira River
 - (e) Lake Delcommune
 - (f) The Upemba Lakes & the Upper Lualaba River
4. Wetlands of the Central Zaire Basin
 - (a) Riverine Swamps & Forests
 - (b) Lake Tumba
 - (c) Lake Mai Ndombe
 5. Wetlands of the Eastern Highlands
 6. Lake Tanganyika & the Ruzizi Plain
 - (a) Lake Tanganyika
 - (b) The Ruzizi Plain
 7. Lake Kivu
 8. Lake Edward
 9. The Semliki River Valley
 10. Lake Albert

1. Wetlands of Bas-Zaire

Country: Zaire

Coordinates: 4°00'-6°00' S/12°20' -16°00' E

Area of Region: c. 65 227 km²

Altitudinal Range: 0-1000 m asl

General: The Atlantic coast of Zaire is generally of high relief, with cliffs along much of its length. Miniature mangrove stands occur where these are breached by little coastal streams, e.g. at the mouth of the Creek de Mosquitos, just north of Banana (5°58'S/ 12°27'E). A short southward facing promontory extends from Banana into the mouth of the Zaire River, sheltering two large, and numerous small, islands in bays on the north shore of the estuary. The islands extend more than 90 km up estuary, past the town of Boma (5°50'S/13°03'E), and are separated from the mainland by broad channels. However, the main stream and channel of the river pass south of the islands, and tidal (mangrove) forests fringe all the channels between the islands and the mainland. They occur in narrow strips, 100-500 m wide, for 30 km up both the 'Crique de Banana' and the 'Crique des Pirates', and are again well developed at Chango Creek 30 km farther upstream. They also cover many sand or mud banks which are emergent at low tide, but are best developed on mainland shores where

small streams enter the estuary. Spring tidal amplitude is 1.7 m at the mouth, 1.5 m at Quissanga, 0.85 m at Mateba and 0.08 m at Boma near where the estuarine section ends and to where mangroves extend.

Cliffs rise to 244 m asl on the north bank of the river near Matadi, and upstream of this place, 150 km from the ocean, the first torrential section is encountered, extending for some 60 km between Yellala Falls and Isingila Falls, with many rapids. From here, in proceeding farther upstream, the river is generally more tranquil, although deep, with a strong current, and confined to a narrow bed for nearly 170 km. Although there are turbulent patches the second major torrential section is not encountered until Manyanga Falls, from where it extends for another 55 km upstream to the vicinity of Sanga. Above Sanga, the river is less turbulent, but still deep, confined to a narrow bed and swift flowing, until Malebo Pool is reached after a further 75 km.

The Pool is 25 km wide and 35 km long, occupying a depression encircled at a distance by hills rising to 500 m asl, while the water level in the Pool is close to 300 m asl. The area of the Pool is about 50 000 ha and the central part is occupied by M'Bamou Island (18 000 ha), which is Congolese territory. There are several groups of small islands, and a little archipelago in the channel on the south side of M'Bamou Island, opposite the mouth of the Nsele River, which discharges into the pool. These islands are Zairean territory and are entirely submerged at high water. The southern shore of the pool is swampy for 30 km between the mouths of the Ndjili and Nsele Rivers, with swamps extending 7 km inland at the western side near the Ndjili. Counting the islands, some 10 800 ha of swampland occurs in Zaire on the southern side of the pool. The Nsele is the largest river entering Malebo Pool and swamps extend back up its valley for 22.5 km, with a mean width of 2 km, and then farther upstream, another stretch, some 1.6 km wide, extends for 70 km along the river, totalling some 16 800 ha. The current in the pool is variable but averages 5 km/hr. The pool is shallow with depths of 3-10 m, while water levels vary by as much as 3 m over the course of a year.

Climate: The estuary mouth is comparatively arid receiving only 800 mm rain/yr, while the town of Banana receives a mere 740 mm, but mean annual rainfall increases upstream to 900 mm at Boma, 1023 mm at Matadi and 1374 mm at Kinshasa where the dry season has a duration of about 120 days. The hills on either side of the river are wetter than the river valley, receiving 1400 mm on the border with Cabinda, 1498 mm at MbanzaNgungu (5°17'S/14°51'E) on the south side, and nearly 1600 mm over the upper valley of the Nsele River on the Angolan border. The mean annual temperature at Banana is 25.2°C, while the absolute maximum recorded is 33.6°C and the absolute

minimum 15°C. Corresponding figures for Matadi are 23.5, 35.4 and 15.2°C, while for Kinshasa at the eastern end of the region on the banks of Malebo Pool they are 23.3, 33.3 and 13.2°C. In the hills to the south of the river, at Mbanza-Ngungu, they are 23.1, 37.5 and 9.8°C. Malebo Pool experiences 1650-1700 hours of sunshine each year, with monthly figures of 120-150 hours. During the dry season the wind at Malebo Pool is consistently from W or SW, but it is more variable during the wet season.

Water Quality: Poll (1959) quotes the water temperatures at Malebo Pool in September 1957 as being 27.3°C at the surface and 27.4°C at 3 m depth, when the air temperature was 26.8°C. The water is turbid with Secchi depths of about 50 cm. It is analysed monthly at Kinshasa and the mean figures for the year 1976-77, in mg/l, were calcium 2.23; magnesium 0.86; sodium 1.99; potassium 1.33; bicarbonate 7.11; sulphate 2.0; chloride 2.71 and silicate 9.7. The waters are comparatively well oxygenated. In 1957 Poll obtained a reading of 5.45 mg O₂/l.

Wetland Flora

Tidal Forests: The tidal forests are dominated by *Rhizophora racemosa* in the frontal swamp and by *R. harrisonii* and *R. mangle* in the middle zones, the first two species reaching heights of 25-30 m locally. *Avicennia africana* also occurs in these mangrove swamps, frequently associated with *Laguncularia racemosa*, and on the landward margins, with *Conocarpus erecta*. *Avicennia* occupies some sandy seaward sites near the mouth of the estuary, and occurs along the back of the swamp, behind the *Rhizophora* forest, in downstream sites where the transition to terrestrial vegetation is saline and fairly dry. Other species commonly associated with *Avicennia* along the landward fringe of the mangrove are *Caesalpinia bonduc*, *Chrysobalanus icaco*, *Dalbergia ecastaphyllum*, *Drepanocarpus lunatus*, *Hibiscus tiliaceus*, *Ternstroemia africana* and *Ximения americana*. In upstream sites, and especially where small tributary streams enter the estuary through the mangrove, the *Rhizophora* forest grades into fresh water swamp forests, many of which are weakly tidal. These are dominated by *Pandanus candelabrum* and/or *Raphia vinifera*, the latter often in association with *Phoenix reclinata* and the spiny climbing palms *Ancistrophyllum secundifolium* and *Eremospatha haullevilleana*, which render the vegetation impenetrable. *Raphia* swamps, or raphiales', frequently occur in mosaic with other types of swamp forest throughout Bas-Zaire.

Riparian Associations: Forests subject to semi-permanent inundation occur behind the raphiales along the Zaire Estuary, on almost level banks which slope imperceptibly into the river. These same forests occur on the

Zaire River in placid sites upstream, and also on some of the larger tributaries. Floristically they are usually dominated by *Mitragyna stipulosa*, but are quite diverse, containing such associate species as *Acioa dewevrei*, *Alstonia congensis*, *Anthonotha pynaerti*, *Baikiaea insignis*, *Blighia welwitschii*, *Brazzeia congoensis*, *Bridelia ripicola*, *Dialium pachyphyllum*, *Dichaetanthera africana*, *D. strigosa*, *Eriocoelunz microspermunz*, *Guibourtia demeusei*, *Mallotus oppositifolius*, *Nauclea diderrichii*, *N. pobeguinii*, *Oubanguia africana*, *Parinari glabra*, *Sterculia bequaertii*, *Symphonia globulifera*, *Uapaca heudelotii*, *Voacanga thouarsii* and *Uvariadendron mayumbense*. There is often an understorey of coarse herbs, among which *Marantochloa mannii* and *M. hensii* are important.

A type of swampy gallery forest, subject to less permanent inundation, is found on rivers in deep valleys cut into impermeable polymorphic sandstones in the hills south of the river. Here, *Syzygium gilletii* and *S. guineense* ssp. *huillense* are the dominant trees, generally accompanied by *Anthocleista liebrechtsiana*, *Bertiera laurentii*, *Coelocaryon botryoides*, *Dichaetanthera corymbosa*, *Gaertnera leucothyrsa*, *Quassia undulata*, *Raphia sese*, *Uapaca guineensis* and *Xylopia rubescens*. *Ancistrophyllum secundiflorum*, *Eremospatha cabrae* and *E. haullevilleana* are common climbing palms in this forest, while in the understorey *Impatiens kasaiensis* is perhaps the commonest plant. Numerous ferns and selaginellas grow low down on the tree trunks.

Although, above tidal limits, water levels in the Zaire River do not fluctuate greatly, those of the tributaries in Bas-Zaire have markedly seasonal flows, because they are short rivers and the local climate has a pronounced dry season during the austral winter. They rise in the local hills, but in the case of the Inkisi, far south in Angola. On these rivers gallery forests may be deeply inundated for half the year and dry for the other half. Floristically they are characterised by the abundance of *Dracaena capitulifera* and *Pseudospondias microcarpa*, with *Berlinia bracteosa*, *B. bruneelii*, *Cleistopholis patens*, *Lanea welwitschii*, *Mallotus oppositifolius*, *Mimosa pigra*, *Symphonia globulifera*, *Treulia africana* and *Uvariadendron mayumbense* as common associates.

Pandanus butayei occurs in almost monospecific stands along some minor streams in the Inkisi Basin to the southwest of Madimba (5°00'S/15°08'E). The pandans grow on the stream banks, and where flow rates are not vigorous, possibly even petering out at times during the dry season, they may be seen to have invaded the stream beds, the water flowing through their stilt roots, and around the outside of clumps.

Where small rivers form pools with muddy banks, and along tranquil stretches of the Zaire River, especially on muddy backwaters, there may be a dense bushy pioneer association. This grows on flat banks, in shallow waters or on muddy soil, and is characterised by the dominance of *Alchornea cordifolia* and *Anthocleista liebrechtsiana*, with the presence of other species including *Aeschynomene* cf. *elaphroxylon*, *Clappertonia ficifolia*, *Mimosa pigra*, *Phyllanthus reticulatus* and *Sesbania sesban*. In deeper water *Cyperus papyrus* becomes dominant and large stands occur around Malebo Pool, in the Nsele Valley, and in many small choked valleys of the Luina and Lunionzo Basins. In these latter places, landslips or other local disturbances have led to drainage from the lower parts of valleys being impeded. The papyrus and *Alchornea* associations may abut and even intermingle with each other.

By contrast, sparse herbaceous vegetation occurs on young sand banks and unstable sandy river banks. Various short sedges occur in these situations, together with *Artanema longifolium*, *Cassytha filiformis*, *Eleusine indica*, *Eragrostis atrovirens*, *Glinus oppositifolius*, *Grangea maderaspatana*, *Mitracarpus scaber*, *Portulacaefoliosa* and *Scoparia dulcis*. Most are of wide distribution, pantropical or palaeotropical, and penetrate far upstream into the central Zaire Basin. Where soil is more stable and subject only to the weakest currents, *Phragmites mauritianus* beds develop, or rarely, swards of *Pennisetum nodiflorum*.

In the swift flowing and cataract ridden section of the Zaire River between Matadi and Kinshasa, other low thickets develop in sites subject to frequent but short periods of inundation. Here *Manilkara lacera* and *Pachystela breviceps* are the most characteristic species. They are usually found with some or all of the following: *Baphia verschuerenii*, *Dalbergia louisii*, *Deinbollia laurifolia*, *Eugenia dewevrei*, *Garcinia* spp., *Guibourtia demeusei*, *Ochtocosmus congolensis*, *Phyllanthus reticulatus*, *Schotia bequaertii*, *Strychnos* spp., *Synsepalum dulcificum* and *Xylopia parviflora*. Climbers are abundant in this kind of forest, especially *Agelaea dewevrei*, *Artabotrys pynaertii*, *Calycobolus klaineanus*, *Memecylon* spp., *Popowia littoralis*, *P. oliverana*, *Pouchetia africana*, *P. gilletii*, *Salacia elegans*, *Uvaria dacrernontii* and *Uvariopsis congensis*. These thickets are often very dense.

In the cataract regions, rocks subject to alternate inundation and exposure, and the walls of cascades subject to constant spray, are dominated by bryophytes, with some specialised higher plants belonging to Podostemaceae and Lentibulariaceae. Perhaps the most characteristic of these are *Inversiodicraea tenuissima* and *Utricularia andongensis*.

Where the banks of the Zaire River are sandy but stable, with a high water table but seldom deeply inundated, the riverine forest has a closed canopy up to 25 m high, composed almost exclusively of *Irvingia smithii* and *Parinari congensis*. Frequently this type of forest succeeds the foregoing type. Among the occasional associates are *Allophyllus africana*, *Chrysobalanus atacorensis*, *Dialium excelsum*, *Guibourtia demeusei*, *Trichilia retusa* and *Uapaca heudelotii*. The Araceous climber and creeper, *Culcasia scandens* is frequently abundant, both on the soil and on the boles of the trees. Some woody lianes also occur in this forest type. Mostly they are common to the *Manilkara* thickets described above, and possibly persist from a preceding seral stage.

The edges of quiet lakes and pools, formed for example in abandoned river channels in the lower valleys of some of the tributaries, are often fringed by stands of *Polygonum senegalense* in a transition from aquatic to terrestrial vegetation. The open waters support carpets of *Nymphaea caerulea*, *N. lotus* and *Nymphoides indica*, with *Aponogeton subconjugatus*, and *Trapa natans* var. *bispinosa*. These species are also common in front of *Phragmites* and papyrus in some swamps, for example on Malebo Pool. *Ceratophyllum demersum* and *Utricularia* spp. are common submerged associates. In other places, on acid peaty soils, the margins of small oligotrophic pools are dominated by *Eleocharis acutangula*. These pools are common in the upper parts of some tributary valleys. Numerous species of *Utricularia* are present in the water, and in the most shallow places *Sphagnum* and *Xyris* spp. Calm forest pools are often covered by *Lemna paucicosta*, *Pistia stratiotes* and *Salvinia nymhellula*. *Eichhornia crassipes* and *Salvinia auriculata* have become naturalised on some ponds and rivers. At times floating meadows of the former species have been known to completely obstruct the channel of the Bundi River near its confluence with the Zaire River, and it also forms vast carpets in the swamps bordering Malebo Pool.

Floodplains occur behind the papyrus swamps on the southern shore of Malebo Pool and also in the valleys of the Ndjili and Nsele Rivers. Here typical species which, although rooted, contribute to vast floating prairies, are *Echinochloa pyramidalis*, *E. stagnina*, *Ipomoea aquatica*, *Neptunia prostrata*, *Oryza barthii* and *Vossia cuspidata*.

Non-Riverine Wetlands: Sedge/grass swamps occupy swampy depressions on schisto-calcaerous soils, where surface water is almost permanent. The most common species in these sites is undoubtedly *Echinochloa pyramidalis*, but others which accompany it include *Clappertonia ficifolia*, *Cyrtosperma senegalensis*, *Eulophia angolensis*, *Jardinea congoensis*, *Loudetia flammida*, *Phragmites mauritianus* and

Polygonum salicifolium. Other depressions in savanna regions are covered by almost pure swards of *Setaria anceps*, with species of *Bulbostylis*, *Cyperus* and *Scleria* as the most common associates.

A complex of peat bogs and flat peaty swamps occurs in the upper parts of some river valleys, but are best developed in the eastern parts of the Inkisi Valley on schists and Kalahari sands. Usually these bogs form a mosaic with the acid pools containing *Eleocharis acutangula* described above. They are characterised by an abundance of *Rhynchospora candida*, but with diverse groupings in the ground layer. Here *Sphagnum* spp. and various Eriocaulaceae and Xyridaceae are most common. The species with the highest fidelity are *Mesanthemum radicans*, *Paspalanthus lamarckii*, *Xyris hildebrandtii*, *X. sphaerocephala* and *X. vanderystii*. *Drosera madagascariensis*, *Microchloa kunthii*, *Panicum parviflorum*, *Paspalum comnersonii*, *Utricularia arenaria*, *U. spiralis* and *U. subulata* grow on the elevated hummocks of *Sphagnum*, increasing the diversity of the mosaic. Occasionally the wettest parts of these bogs are invaded by *Andropogon virgatum* and in many sites a graminaceous stratum develops. This is, however, generally composed of *Leersia hexandra*, *Rhynchne rottboellioides*, *Sacciolepis africana*, *Setaria anceps* and *Trichopteryx dregeana*, with a substantial admixture of *Bulbostylis laniceps*, *Cyperus halpan* (= *C. haspan*) and *C. laxispicatus*.

Some circular depressions on the plain of Lukunda are inundated for the greater part of the year, and are covered by a type of swamp forest dominated virtually exclusively by *Irvingia smithii*, with *Holarrhena floribunda* and *Pseudospondias microcarpa* as uncommon associates. The sparse understorey comprises *Grewia seretii*, together with *Cleistopholis patens*, *Glyphaea brevis* and *Memecylon* spp.

Wetland Fauna

Fishes: The fish fauna below Boma has many euryhaline species, e.g. pristids, elopids, sphyraenids and migulids, together with freshwater representatives of predominantly marine families, such as clupeids, gobiids, tetraodonts and the mangrove mudskippers *Periophthalnius* spp., and a number of secondary freshwater cichlids and cyprinodonts. Thereafter the rapids sections provide what are probably the largest expanses of torrential water in the tropics, and here many fish species exhibit special adaptations to fast flowing, dark, well oxygenated water, and are able to spend much of their lives under rocks. Examples are *Gymnallabes tihoni*, a clariid catfish, *Caecomastacenzbalus brichardi*, the cichlids *Leptotilapia rouxi* and *L. tinanti*, also the blind cave fish, *Caecobarbus*

geertsi (Cyprinidae), and species of *Atopochilus*, *Chiloglanis*, *Euchilichthys*, *Garra*, *Labeo*, *Steatocranus* and *Teleogranza*. Adaptations to torrential water are however, not confined to the lower Zaire River. They are found again, involving different species, in the rapids sections of many streams tributary to the upper sections of the river.

Some 235 species of fish have been described from Malebo Pool, of which 5 are sometimes said to be endemic to the pool. The *Mormyridae*, with 36 species in 4 genera, are better represented in Malebo Pool than any other family, both in terms of numbers of individuals and numbers of species. Important mormyrid species are *Gnathognemus greshoffi* and *Mormyrops deliciosus*. Among clupeids, *Microthrissa royauxii* and *Poecilothrissa congica* are important, while characids include species of *Alestes*, *Bryconaeethiops* and *Hydrocynus goliath* and *H. vittatus*. *Barbus pleuropholis* and *Leptocypris modestus* are common cyprinids, and *Chrysichthys crantchii* and *Gephyroglanis longipinnis* are important bottom dwellers. The lungfishes, *Protopterus aethiopicus* and *P. dolloi*, inhabit the swamplands, together with *Phractolemus ansorgei* and several species of *Clarias*, *Micralestes*, *Synodontis* and *Tetraodon*.

Amphibia: The swamps throughout Bas-Zaire support large and diverse amphibian populations, with many species of frogs and toads.

Reptiles: Among the aquatic or semi-aquatic reptiles are *Antyda* sp., *Boulengerina annulata*, *Crocodylus cataphractus*, *C. niloticus*, *Naja melanoleuca*, *Pelonedusa* sp., *Pelusios* sp., *Psammophis sibilans*, *Python sebae* and *Varanus niloticus*, while *Dasypeltis fasciata*, *Dendroaspis janiesonii*, *Philothamnus semivariiegatus* and *Thelotornis kirtlandii* are arboreal in swamp and gallery forests.

Birds: The avifauna of the swamps, rivers, lakes, swamp forests and palm swamps is rich and comprises several hundred species, many of which are found throughout the central Zaire River Basin. Widespread species, including migrants, include *Acrocephalus arundinaceus*, *A. schoenobaenus*, *Actitis hypoleucos*, *Anas* spp., *Anastomus lamelligerus*, *Anhinga rufa*, *Apus apus*, *Ardea melanocephala*, *A. purpurea*, *Ardeola ralloides*, *Bias musicus*, *Botaurus stellaris*, *Butorides striatus*, *Callidris nzinuta*, *Ceryle rudis*, *Chlidonias leucoptera*, *Corythornis cristata*, *Egretta intermedia*, *Ephippiorhynchus senegalensis*, *Gallinago media*, *Glareola nordmanni*, *Haliaeetus vocifer*, *Halcyon leucocephala*, *Hieraaetus spilogaster*, *Hirundo rustica*, *Ixobrychus minutus*, *Lanius collurio*, *L. minor*, *Larus fizscus*, *Megaceryle maxima*, *Merops apiaster*, *Motacillaflava*, *Muscicapa striata*, *Nycticorax nycticorax*, *Pandion haliaetus*, *Phalacrocorax africanus*, *P. carbo*, *Phylloscopus trochilus*, *Riparia riparia*, *Rynchops flavirostris*

and *Tringa glareola*.

Mammals: Among the mammals *Hippopotamus amphibius* is rare, having virtually disappeared from Malebo Pool, but *Aonyx congica*, *Atilax paludinosus*, *Dasymys bentleyae*, *Lutra maculicollis*, *Potamochoerus porcus* and *Tragelaphus spekei* are common. Several monkeys live in the gallery forests, palm swamps and seasonally inundated forests of Bas-Zaire, e.g. *Cercocebus torquatus*, *Cercopithecus aethiops cynosurus*, *C. ascanius* (south of the Zaire River), *Cercopithecus cephus*, *Colobus polykomos angolensis* and *Miopithecus talapoin*, the latter pair occasionally found in the mangroves.

Human Impact & Utilisation: Two large cities are situated on the edges of Malebo Pool, Brazzaville in Congo, with a population of 300 000, and Kinshasa in Zaire, with a population of 3 500 000. Both towns are important ports, serving centres upstream, and over a million tons of merchandise pass through them each year. Human influence on Malebo Pool is therefore quite pronounced, and the local fishery lands catches of 1500-2000 tonnes/yr. Further, and particularly in Zaire, most of the land escaping annual inundation has been cleared for agriculture or horticulture, but there has been comparatively little destruction of the swamps. Away from the cities, towns and villages have grown up on the edges of floodplains, and the seasonally flooded areas are utilised in various ways during the dry season, and are fished during the wet. In the estuarine section, both Boma and Matadi are ports, Boma serving the north shore and Matadi, which is linked to Kinshasa by rail, serving the south. The mouth of the estuary is sparsely populated. Inland, while most forest types in Bas-Zaire have suffered serious deprecations, swamp forests have largely escaped, since they have, until very recently, been deemed valueless. Now some clearing is being undertaken for rice production.

Conservation Status: A small area of the Mayumbe Massif in Bas-Zaire north of the Zaire River, approximately 5°35'S/13°10'E, and containing the headwater areas of the Luki River, is protected in the Luki Forest Reserve. However, little wetland is found here, and much of the forest in the reserve is of secondary character. Total protection for the forest has been in operation since 1963, when all felling ceased. Hunting and fishing are also prohibited.

2. Wetlands of South Bandundu, Kasai Occidental & Oriental

Country: Zaire

Coordinates: 4°15' -8°00'S/16°00' -26°00' E

Area of Region: c. 401 175 km²

Altitudinal Range: 450-1150 m asl

General: All parts of this region experience a dry season of 100-130 days duration, and a rainfall of between 1400-1750 mm/yr. There is a double periodicity over most of the region. December and March are the wettest months, when respective falls of 200-250 mm and 180-230mm are received. Mean monthly temperatures are in the region of 23°C, rising to 24-25°C in the wet season. Daily temperature range is greater in the dry season than the wet, with mean maxima and minima close to 32 and 15°C in July, while the corresponding figures for December are 29 and 19°C. Absolute maxima at most stations are in the region of 37°C and absolute minima in some southern stations is below 9°C.

The area is drained by many rivers and their innumerable tributaries, all eventually flowing in parallel, northwards off the southern plateau. The largest of these are, from west to east, the Kwango (Cuango), Kwilu (Cuilo), Loange, Kasai, Lulua, Kelagne Bushimaie, Lubilash and Lomami Rivers, but between the Kwango and Kwilu alone, there are no less than 9 major streams, the Wamba, Bakal i, Konzi, Inzia, Luie, Lukula, Kafi, Gobari and Kwenge Rivers. All except the Lomami eventually discharge into the Kasai, which, north of the area presently under consideration, swings westwards and skirts the southern border of the central Zaire depression. The individual swamps in this geographic region are too numerous to be described in detail. Periodically or permanently inundated lands follow the lowest parts of all the river valleys, in strips 100 m to 10 km wide. There are for example 11 major swamps, totalling some 155 000 ha, on the Kwilu River and its tributaries between 6-7°S, together with many minor swamps, and there is no less than 450 000 ha of wetland in the vicinity of Sandoa (9°41'S/22°56'E) associated principally with the drainage basin of the Lulua River at altitudes of 750-1050 m asl.

Wetland Flora

The region is characterised by extensive savanna plains with gallery forests along the rivers, but with more extensive valley bottom forests towards the central Zaire depression. The savannas are dominated by a *Julbernardia-Brachystegia* association in the south, reaching latitudes of 7°20'S in places, but farther north this gives way to other associations, e.g. a *Tristachya nodiglumis-Diectomis fastigiata* association in the west, and an *Encephalartos poggei-Smilax kraussiana* association in the east. Large blocks of pseudo-steppe vegetation interdigitate with these, characterised by *Aristida vanderystii* and *Boopane disticha*. Most of the valley bottom forests are periodically inundated, but some, in depressions, are inundated almost permanently. Numerous grass, reed and papyrus swamps occur in the upper valleys, with extensive peat bogs in some choked valleys, and in very shallow depressions on plateau areas. There are also substantial areas of hygrophilic

grassland.

Riparian & Floodplain Associations: In southern Bandundu, sandy banks in and along major rivers, subject to periods of inundation by quite swiftly flowing water, are colonised by a woody *Malouetia bequaertiana-Uapaca heudelotii* association, forming dense thickets adjacent to the water. The principal associates are *Berlinia giorgii*, *Cathormion altissiina*, *C. obliquifoliolata*, *Dioclea reflexa*, *Homalium ealaense*, *Irvingia sniithii*, *Mucuna flagellipes*, *Opilia sparsiflora*, *Syzygium guineense* and *Uvariopsis congensis*. Here are to be found a number of epiphytes, including *Ancystrorhynchus clandestinus*, *Angraecum distichum*, *Asplenium africanum*, *Calypstrochilunz emarginatum* and *Platynerium stemaria*. Elsewhere, *Alchornea cordifolia* is the pioneering woody species.

Along the banks of the big rivers, north of the parallel 5°S, one encounters outliers of floodplain forests dominated by *Lannea welwitschii*, *Monopetalanthus pterydophyllus*, *Pseudospondias microcarpa*, *Rauvolfia mannii* and *Thomandersia laurifolia*. They occur on alluvium and are found to intercalate with the association previously described, and a *Gilbertiodendron dewevrei* association, which dominates the valley sides and extends down onto the fringes of the floodplain.

The lowest parts of valley floors in this region are occupied by swamp forests and several distinct types can be recognised. Wide galleries of swamp forest occur along rivers in broad valleys on impermeable polymorphic sandstones, which ensure that the soil surfaces are permanently waterlogged. The most characteristic species are *Newtonia devredii* and *Uapaca guineensis*. These forests are primitive in character and provide a refuge for several Guinean species, the distribution of which was significantly constricted during the Quaternary. Some other species commonly found in these galleries are *Acioa dewevrei*, *A. lujae*, *Berlinia grandiflora*, *B. sapinii*, *Dacryodes edulis*, *Dalbergia louisii*, *Epinetrum villosum*, *Eriocoelum microspermum*, *E. petiolare*, *Homalium inolle*, *Mitragyna stipulosa*, *Monopetalanthus pteridophyllus*, *Paramacrolobium coeruleum*, *Pararistolochia promissa*, *Parinari glabra* and *Symphonia globulifera*, together with species of *Anthonotha*, *Chrysophyllum*, *Culucasia*, *Dialium*, *Lonchitis* and *Nephrolepis*.

In ravines and deep narrow valleys, swamp forests cling to the courses of streams and are dominated by *Mitragyna stipulosa* with *Sarcophryniurn schweinfurthianum* a feature of the ground layer. *Sterculia bequaertii* and *Symphonia globulifera* are the principal associates. At the heads of broad trough-like valleys swamp forests are dominated by *Xylopi rubescens*, with

several species of *Syzygium*. The flanks of these forests tend to comprise *Syzygium cordatum* and *S. parvifolium* in narrow girdling belts, while in the interior *Syzygium giorgii* is the typical associate. On the banks of swift flowing rivers, subject to sudden high floods, *Pandanus butayei* sometimes forms long monospecific stands. However, in the upper reaches of the Kwango River, where the river is deeply entrenched in the vicinity of Swa Tende (7°14'S/17°07'E), below the two waterfalls of Kasondo-Lumda and Guillaume, *Raphia laurentii* (= *R. monbuttorum*) swamps cover the valley floor.

Along the sandy courses of lower reaches of the eastern rivers in Kasai, e.g. the Lulua and Sankuru Rivers, the banks subject to frequent inundation and rapid changes in water level are colonised by woodland in belts several kilometres wide. Here the lower stratum is discontinuous and poorly developed and there are scattered patches of herbs. The spectrum of species differs from that in the west of the region and typically includes *Acioa lujae*, *Alsodeiopsis poggei*, *Baikiaea insignis*, *Berlinia sapinii*, *Cathormion altissimum*, *Cynometra pedicellata*, *Gilletiodendron inildbraedii*, *Gouania africana*, *Hexalobus crispiflorus*, *Irvingia smithii*, *Morelia senegalensis*, *Ouratea arnoldiana*, *Tessmannia dewildemaniana*, *Uapaca heudelotii* and *Uvariopsis congensis*, with the lianes *Oxymitra sayauxii* and *Pleioceras gillettii*. In the herbaceous stratum one finds *Dracaena poggei* and *Hypolytrum heterophyllum*.

In depressions away from rivers on floodplains, on the land behind levees, and in wet valley heads, sandy lithosols are frequently colonised by a well stratified swamp forest attaining 20 m in height. This contains a range of species, but is given special character by the presence in its canopy of an abundance of *Syzygium guineense* ssp. *guineense* and *Voacanga thouarsii*. The forest is heliophilic, generally has a second stratum at a height of 10-15 m, a bushy layer at 2-5 m, and a ground layer up to 1.5 m high. In addition to the two species already cited, the most characteristic trees of the upper strata are *Ficus congensis*, *Gardenia imperialis*, *Mitragyna stipulosa*, and locally *Elaeis guineensis*. In the lower strata, *Adenostemma viscosum*, *Costus lucanusianus*, *Cyclosorus striates*, *Nephrolepis biserrata* (growing terrestrially), *Orestias foliosa* and *Scleria racemosa* are common. *Adenia dinklagei* (Passifloraceae) and *Culcasia scandens* (Araceae) are bole climbers, while *Pleopeltis scolopendria* grows epiphytically. Upstream this woody association frequently gives way to an herbaceous swamp dominated by the hygrophilous grasses *Loudetia phragmitoides* and *Trichopteryx dregeana*, which may extend to the very head of the valley.

The woody vegetation just described tends to be succeeded by a climax

swamp forest, with a canopy exceeding 30 m in height and providing up to 90% cover, with a lower arborescent stratum at 15-20 m. An abundance of *Coelocaryon botryoides* and *Uapaca guineensis* typify this forest, but other co-dominants include *Alstonia congensis*, *Baikiaea insignis*, *Eriocoelunz microspermum*, *Macaranga saccifera*, *Mitragyna stipulosa*, *Parkia filicoidea*, *Raphia* spp., *Rothmannia megalostigma*, *Strombosiopsis tetrandra*, *Symphonia globulifera* and *Treculia africana*. Climbing palms, *Ancistrophyllum* and *Eremospatha* spp. also reach the canopy. *Pauridiantha pyramidata* dominates the understory, but is associated with *Ataenidia conferta*, *Cyrtosperrna senegalense*, *Dicellandra barberi*, *Marantochloa congensis*, *Menzecylort myrianthum*, *Napoleana imperialis*, *Sarcophrynium schweinfurthianum* and *Xylopia acutiflora*. *Anthoclitandra robustior*, *Aroxima congolana*, *Cercestis congoensis*, *Microsorium punctatum*, *Milletia gossweileri* and *Popowia bicornis* grow either as climbers or epiphytes, together with those species mentioned in this context in the preceding paragraph. This type of forest occupies the sites in gallery forests where the soils are permanently waterlogged. The narrowness of most valleys limits the extent of this forest type, which is seldom great.

Hygrophilous evergreen forests, dominated by *Gilbertiodendron dewevrei*, occur on alluvial flats which may be waterlogged for much of the year, but flooded only briefly. These forests attain heights of 20-30 m and are generally well stratified. While *Gilbertiodendron* comprises the canopy layer almost exclusively, it has associates in the upper strata, notably *Alphanocalyx cynometroides*, *Garcinia smeathmannii* and *Monopetalanthus microphyllus*. Occasionally relict species from swamp forest may be present, indicating that the area once supported this type of vegetation. Perhaps the most common of the relict species are *Asystasia vogeliana*, *Dicranolepis oligantha*, *Eremospatha haullevilleana*, *Palisota thyrsoflora* and *Raphia* spp. Among lianes, *Agelaea dewevrei*, *Anthoclitandra robustior*, *Jaundea pubescens* and *Landolphia foretiana* are most abundant.

Elsewhere, e.g. in the vicinity of Mweka (4°51'S/21°34'E), hygrophilous semi-deciduous forests occupy this same habitat, with an abundance of *Austranella congolensis*, *Cynometra hankei*, *Julbernardia seretii* and *Scorodophloeus zenkeri*, and the two forest types may intergrade.

Where periodically inundated swamp forest has been cleared by man in the more elevated regions, between 6-8°S, and has not been able to regenerate, it tends to be replaced by a *Loudetia phragmitoides* grassland, containing characteristically the labiate, *Briquetastrum africanum*. This latter association occurs in the west, between the Kwango and Kwenge Rivers, but is especially common in Kasai Oriental, to the NE of Dibaya, where the landscape is highly dissected. The association comprises only herbs and

suffrutescent species. In addition to the two species already cited, the following are important: *Acriulus grigiifolius*, *Aeschynomene sensitiva*, *Andropogon tenuiberbe*, *Crassocephalum picridifolium*, *Crotalaria sessilis*, *Cyclosorus striatus*, *Cyperus auriconzus*, *C. distans*, *C. latifolius*, *C. laxispicatus*, *Desmodium Dissotis princeps*, *Eriochrysis brachypogon*, *Eulophia latilabris*, *Fimbristylis miliacea*, *Fuirena umbellata*, *Hydrolea guineensis*, *Hyparrhenia bracteata*, *Hypogynium spathiflorum*, *Kotschya stolonifera*, *Kyllinga pungens*, *Otometria elatior*, *Panicum nervatum*, *Rhynchospora candida*, *R. corymbosa*, *Scleria melanomphala*, *Selaginella congoensis*, *Trichopteryx dregeana* and *Vigna nigrita*. This marshy association is generally bounded by a monospecific band of *Loudetia simplex*, 10-20 m wide.

Shady backwaters along rivers and ponds in swampy riverine forests support a *Lemna paucicosta*-*Pistia stratiotes* association. Many rivers, e.g. much of the Kwango, are fringed along the waters edge by meadows of *Echinochloa pyramidalis* with an abundance of *Polygonum senegalense*. A variety of vegetational types occur on hydromorphic soils in broad sandstone valleys, especially above some of the waterfalls where the river water spreads in a thin sheet over a large area. In places the waterlogged soils extend in flat belts, 2-3 km wide, along the rivers, and here the several associations are determined primarily by edaphic factors. Where there is often a sheet of free water at the surface, *Aeschynomene fulgida* is common in association with *Craterostigma goetzii*, *Dissotis debilis*, *Emelia* sp., *Fuirena unbellata*, *Heteranthoecia guineensis*, *Leersia hexandra*, *Rhynchospira rottioides*, *Sacciolepis typhura*, *Sphagnum planifolium*, *Stipularia africana*, *Utricularia* spp., *Trichopteryx dregeana*, *Xyris hildebrandtii* and *X. imitatrix*.

On sandy rivers those parts of shallow banks which are periodically submerged are colonised by dense beds of *Rhynchospora candida*, together with *Axonopus compressus*, *Drosera* sp., *Eriochrysis brachypogon*, *Mesanthemum radicans*, *Paepalanthus poggeanus*, *Sphagnum planifolium*, and species of *Torenia*, *Utricularia* and *Xyris*. In adjacent situations lawns develop on superficially swampy sites, being characterised by the presence of *Craterostigma latibracteatum* and *Neurotheca longidens*, together with *Andropogon huillensis*, *Eragrostis plurigluma*, *Melinis macrochaeta* and *Panicum lindleyanunz*. In river valleys, where the sheet of groundwater remains close to the surface throughout the dry season, *Dissotis thollonii* and various sedges predominate.

Non-Riverine Wetlands: An association of very wide distribution throughout the region under consideration is distinguished by the presence of *Loudetia vanderystii*. It occurs on a range of hydromorphic

soils, away from the immediate vicinity of rivers, but its precise floristic composition depends upon water levels, the duration of the dry season, local edaphic and climatic conditions and geographic location. Among the many species found in this type of vegetation the following are representative: *Andropogon huillensis*, *Aristida atroviolacea*, *Ascolepis protea*, *Bulbostylis pumila*, *Commelina umbellata*, *Crotalaria glauca*, *C. sessilis*, *Cyperus lanceolata*, *C. serpens*, *C. tenax*, *Elyonurus brazzae*, *Eragrostis racemosa*, *Fimbristylis dichotoma*, *F. umbellata*, *Gladiolus nzelleri*, *Glinus oppositifolius*, *Helichrysum alismatifolium*, *Hypogynium spathifolium*, *Kyllinga erecta*, *Panicum brazzavillense*, *P. ianthum*, *Polygala claessensii*, *P. ukirensis*, *Pycreus scaettae*, *Rhynchne rottboellioides*, *Scleria hirtella*, *Schizachyrium mukulense*, *Setaria restioides*, *Sporobolus barbigerus* and the arborescent *Syzygium guineense* ssp. *huillense*. In places Xyridaceae are dominant with *Xyris hildebrandtii*, *X. inzitatrix*, *X. sanguinea* and *X. vanderystii* well represented. In the wettest sites Eriocaulaceae are prominent, e.g. *Synognanthus poggeanus* and *S. walbergii*. This vegetation often has two strata, an upper one 100-150 cm high and a lower one 30-40 cm high, with occasional clumps of trees. Generally this association is confined to alluvial deposits of white oligotrophic sands, in which, as the level of the water table varies from season to season, the upper layers are subject to alternate periods of anoxia and aeration. Surface waters may at times reach depths of 20-40 cm.

In southern Bandundu the waters of ponds on the granite massifs support an *Azolla pinnata* association. Other ponds, open to higher insolation, are covered by *Nynzphaea* spp., and are fringed by *Cyperus papyrus* with low growing *Cyclosorus striatus* and *Vossia cuspidata* in the water at the bases of the culms. Permanent swamps of this latter type are well developed in the Tungila Valley.

Wetland Fauna

The fish faunas of the rivers and swamps are strongly affiliated to those of the central Zaire Basin, but since the rivers of the region under consideration here all have rapids or waterfalls, and are all tributary to the Kasai which enters the Zaire River in the Chenal section, the faunas of their upper reaches differ from that of the middle Zaire River. Most subsystems of the Kasai are thought to have high proportions of endemic species, although only a few have been investigated in any depth. However, of 60 species described from the upper Kasai River, 19 are endemic (Poll, 1963). The presence of Zambezian fish in the Kasai system suggests that at some point in its history the river, or one of its tributaries, captured the headwaters of a stream which once flowed into the Zambezi. Many of the

Kasai rivers share a watershed with the Zambezi and its tributaries. *Aplocheilichthys* and *Hypsopanchax* are genera confined to rivers flowing through savanna country, while *Aphyosemion* and *Epiplatys* (all Cyprinodontidae) are genera found in the lower reaches of rivers traversing tropical rain forest.

Frogs and toads are abundant throughout the wetlands. The reptile and bird faunas of this region are similar to those described in section 1, Bas-Zaïre. Mammals present in the swamp and gallery forests are *Aonyx congica*, *Atilax paludinosus*, *Cephalophus monticola*, *C. sylvicultor*, *Cercocebus aterrimus*, *Cercopithecus aethiops cynosurus*, *C. ascanius*, *C. mona pyrogaster*, *C. neglectus*, *Colobus polykomos*, *Dasymys* sp., *Funisciurus pyrrhopus*, *Galago demidovii*, *Hippopotamus amphibius*, *Leptailurus serval*, *Miopithecus talapoin*, *Nandinia binotata*, *Pan paniscus* (pygmy chimpanzee), *Pellomys fallax*, *Potamochoerus porcus*, *Potamogale velox*, *Sylvicapra grimmia*, *Syncerus caffer*, *Tragelaphus scriptus* and *T spekei*.

Human Impact & Utilisation: Much primary forest has been disturbed, having been exploited by the indigenous people traditionally, and since the middle of this century by Europeans. The Europeans exported huge quantities of timber during the second world war, subsequent to which intensive exploitation has continued along the railway line from the port of Ilebo on the Kasai River, to Kananga, Kamina, Bukama and Lubumbashi. In this region some wet forested areas cut through a long time ago have been reduced to a *Carapa procera* woodland with an understory of *Ananas sativa*.

Conservation Status: Unprotected.

3. Wetlands of Shaba Province

Country: Zaïre

Coordinates: 8°00'-13°30'S/22°00'-29°40'E

Area of Region: c. 321 120 km²

Altitudinal Range: 590-1889 m asl

General: Shaba is situated in the extreme SE of Zaïre where much of the land is over 1000 m, and several elevated blocks rise to over 1500 m asl. The largest of these are the Plateau of Manika and the Kundelungu Mountains, both oriented SW-NE and roughly parallel to each other. On either side of these highlands, and between them, are large swampy depressions. Lake Mweru and the Luapula Floodplain lie to the east of the Kundelungu Range, the headwater swamps of the Lufira River lie between the highland blocks, and the Upemba lake system lies to the west

of the Manika Plateau in the Kamolondo Depression. The border with Zambia and then Angola follows a watershed eastwards across the south of Shaba Province, and for most of the way, is very wet and swampy.

(a) The High Plateau Country

Country: Zaire

General: Above 1000 m, the valleys of most streams carry dambo or dembo vegetation in their uppermost reaches, sometimes with central strips of low forest along the watercourses. Along the southern border the commonest tree in these strips is *Acacia caffra* var. *campylacantha*, and downstream broad galleries of this species replace the dembo vegetation. Here the periodically flooded forest may reach widths of several kilometres, but frequently within it there are expanses of open water along the stream bed, covered by *Nymphaea* spp., or there may be extensive stands of *Typha domingensis*, or mixed stands of short sedges, *Cyperus papyrus* swamps, reedbeds of *Phragmites mauritianus* or aquatic meadows dominated by *Leersia hexandra* and *Echinochloa stagnina*. The Muniama River near Lubumbashi provides a good example of such a valley floor, occluded by *Acacia caffra* forest, but with broad central herb swamps. On other watercourses herbaceous swamps completely dominate the valley floors, and arborescent vegetation is only poorly developed, e.g. on the Kafuba and Kisanga Rivers, also near Lubumbashi, in an area where wetlands account for more than 6% of the land surface.

The deeply dissected highland block to the west of the Kamolondo Depression, centred on Kamina (8°46'S/25°00'E), where the Lubilash, Lumembe, Lomami and Lovoi Rivers rise, is covered by dry savanna forest, with gallery forest along the rivers. *Pandanus candelabrum* forms depleted galleries near Tshibonde and Mwadi-Kayembe, but forests dominated by *Canarium schweinfurthii* with an understorey of *Mellera lobulata* (Acanthaceae) occur along watercourses in the deeper valleys, while *Mitragyna stipulosa* and *Spondianthus preussii* are predominant in the broader ones. Grassy floodplains occur where inundation is deep and prolonged, and in these places the watercourses frequently carry a *Pandanus candelabrum*-*Thalia welwitschii*-*Floscopa glomerata* association. This may be followed on higher ground by a *Pennisetum purpureum* zone, or a *Cyperus latifolius*-*Rhynchospora triflora* zone, and these in turn by *Loudetia kagerensis*-*Fimbristylis gabonica* zones. Patches of *Centratherum englerianum* (Compositae) and *Hyparrhenia bracteata* also occur in the least deeply flooded areas.

Highland bog pools, such as are found on the Manika and Kundelungu Mountain plateaux, contain *Drosera madagascariensis*, *Nyphaea*

sulphureus, *Utricularia* spp., and are fringed by various sedges. Montane stream sides are often lined by thin beds of *Phragmites mauritianus*, while *Psychotria mushiticola* is a common stream side tree at altitudes above 1400 m.

The Kundelungu National Park, an integral nature reserve, protects the southern plateau of the Kundelungu Mountains, the 400 m escarpment by which they fall to the Lufira Valley, and a narrow strip of valley floor beneath the escarpment. On the plateau various pools and areas of bog are protected, and the courses of some minor streams, tributary to the Lufira River, are protected together with their gallery woodlands.

(b) Lake Mweru

Country: Zaire

Coordinates: 8°29' -9°28' S/28°23' -29°10' E

Area: c. 200 000 ha open water in Zaire

Altitude: 919 m asl

Nearest Towns: Pweto (at N end lake); Lubumbashi (280 km SW)

General: Lake Mweru is an almost rectangular lake, 120 km long and 48 km wide, situated in SE Zaire, on the border with Zambia, at the end of the broad Luapula Floodplain. The national boundary crosses the lake from SW-NE and approximately half of the open water surface is in Zaire. The lake is quite shallow, increasing in depth from south to north. Over the southern half the mean depth is 3 m, while in the northern half it is 10 m, with a maximum recorded depth of 37 m. The lake contains several islands but the principal ones are Zambian territory. About 155 km of shoreline is situated in Zaire, on the western and southern sides of the lake. The western shoreline *is* steep, with low cliffs broken by scattered bays, but the southern and southwestern shores are flat and swampy, and dip very gently into the lake. The lake is filled by the Luapula River and several lesser streams which enter the lake in this region, and is drained by the Luvua River, which leaves the lake immediately SW of Pweto.

Climate: Mean annual rainfall over the lake is 1020-1120 mm depending upon site, but higher in the catchments. December is the wettest month, with falls of up to 275 mm, and the rainy season persists for about 195 days. Mean annual temperature at the lake is 22-23°C depending upon site. October is the warmest month with mean daily maxima of 31-34°C and mean daily minima of 18-19°C. July is the coolest month with a mean temperature of 20°C and mean daily maxima and minima of 28°C and 14°C. Sunshine receipts are in the region of 2600 hours/yr, with a monthly maximum of 310 hours in July and a minimum of 125 hours in December. Incident radiation approximates 170 Kcal/cm²/yr on the

lake and evaporation from the lake surface has been estimated as 1700 mm/yr.

Hydrology & Water Quality: The drainage basin, for which Lake Mweru forms a collecting point, is vast, up to 500 km wide and 550 km long with a total area of some 200 000 km². The waters of the lower Luapula are high from March to May, and low between September and January. A maximum flood level of 8 m has been recorded at Kasenga (10°22'S/28°45'E), but the mean maximum level is 3.8 m at this point. The waters of the lake itself are high from April until July, reaching their lowest between October and February. The mean annual fluctuation is 1.5 m, but a maximum variation of 4.7 m has been recorded. Water leaving the lake via the Luvua, enters the Lualaba and eventually the Zaire River en route to the Atlantic Ocean.

The lake is polymictic. Surface water temperatures reach 25-30°C during October-May, but fall to 22-25°C during June-September. Secchi depths vary from 0.6-1.46 m, and total dissolved solids amount to 41-69 mg/l depending upon the season. The pH of lakewater varies between 7.0-9.3, while in the swamps it is 6.0-6.9. The lake is well oxygenated, the surface waters containing 5.4-8.9 mg O₂/l depending upon the season.

Wetland Flora: Hydrophytes in the lake include *Azolla pinnata*, *Ceratophyllum demersum*, *Lagarosiphon ilicifolius*, *Najas pectinata*, *Nymphaea caerulea*, *N. lotus*, *Pistia stratiotes*, *Potamogeton* spp., *Ottelia* spp., *Utricularia* spp., and *Vallisneria spiralis*. Beds of aquatic grasses, including *Echinochloa* spp., *Leersia hexandra* and *Vossia cuspidata*, occupy the lowest levels of the seasonally inundated zone around the lakeside, and are backed by *Cyperus papyrus* in sites along the southwestern shore, with *Phragmites mauritianus* and *Typha domingensis* as typical associates. Rocky shores are dominated by Chlorophyceae, with some hygrophilous herbs at higher levels, including species of *Alternanthera*, *Ipomoea* and *Oldenlandia*.

Wetland Fauna: The fish fauna of the system is diverse. 146 species have been described from the system, 94 from Lake Mweru. There are numerous representatives of Characidae, Cichlidae, Clariidae, Cyprinidae and Mormyridae. *Oreochromis macrochir* is the most important economic species in Lake Mweru, the adult fishes living a pelagic life mainly in the deeper waters of the northern part of the lake, while the juveniles tend to be confined to bays and swamps in the south where they shelter among the floating vegetation, especially *Vossia*. The adults migrate south to spawn from August-September, and remain in the area until January-February. Other species important to the fishery are *Labeo*

altivelis, which migrates up rivers to spawn, and *Alestes macrophthalmus*, which seems to comprise two populations, one which spawns in swiftly flowing waters of the Kalungwishi River (in Zambia) and one which spawns in Lake Mweru itself.

Amphibia are abundant, and reptiles in Lake Mweru include two species of crocodiles, *Crocodylus cataphractus* and *C. niloticus*, which are both considered vulnerable, and the aquatic snake *Boulengerina annulata*. Man-eating crocodiles are a problem on parts of the southern lakeshore. The avifauna of the lake and its environs is rich. Very many of the typical Central African wetland species occur here, including most of those listed in section 1, Bas-Zaire, together with *Actophiloritis africana*, *Ardea goliath*, *Balaeniceps rex*, *Dendrocygna viduata*, *Musciscapa aquatica*, *Pelecanus onocrotalus*, *Phoeniconaias minor*, *Phoenicopterus ruber*, *Ploceus pelzelni* and *Porzana pulsilla obscura*. *Acrocephalus schoenobaenus*, *Chlidonias leucoptera* and *Larus fuscus* are palearctic migrants.

Hippopotamus amphibius is found in the southern parts of the lake, while several small mammals, e.g. *Atilax paludinosus* and *Lutra maculicollis* are more widely distributed.

Human Impact & Utilisation: The lake waters are fished from both Zambian and Zairean sides, the catches being exported to Copperbelt towns in Zaire, to the SW of the lake.

Conservation Status: Unprotected.

(c) The Luapula Floodplain

Country: Zaire

Coordinates: 9°23'-12°00'S/28°29'-28°47'E

Area: c. 330 000 ha

Altitude: 919-980 m asl

Nearest Towns: Kasenga (on upper floodplain); Lubumbashi (190 km SW)

General: The Luapula Floodplain begins at Chembe (12°00'S) where the river descends below the 1000 m contour. The floodplain is oriented due N-S and extends for almost 300 km along a section where the river forms the border with Zambia. However, for the first 180 km from Chembe to Kasenga (10°22'S/28°45'E), it is confined by a narrow valley. Peak water level rises of 8 m have been measured at Kasenga, with a mean annual rise of 3.8 m, but from here north the floodplain widens, and in places a wetland

extends 46 km west of the river on the Zairean side of the border. The floodplain includes several peripheral lakes and numerous riverside lagoons, and substantial areas of permanent swamp. These latter fringe some of the lakes and lagoons, occupy abandoned river channels and extend back as riparian swamps along several tributaries flowing east from the Kundelungu Mountains to the Luapula. The most important tributaries are the Lutsipushka and Kalala Rivers, the former with 46 km of riparian swampland. The largest of the lakes is almost circular with a diameter of 7 km, and three others are more than 5 km long.

Wetland Flora: Papyrus swamps fringe lagoons along the Luapula and dominate large areas of permanent swampland, with the typical associate species *Phragmites mauritianus* and *Typha domingensis*, and the aquatic grasses *Echinochloa stagnina* and *Vossia cuspidata*. Other tall grasses found in the swamps include *Miscanthidium violaceum* and *Pennisetum purpureum*. Wetland herbs found in the swamps in shallow water, and in rafts of floating vegetation, include *Cyperus imbricatus*, *Ethulia conyzoides*, *Ludwigia leptocarpa*, *Melanthera scandens* and *Polygonum senegalense*. The most important floodplain grasses are *Oryza barthii*, which occupies the most deeply flooded sites, and *Echinochloa pyranzidalis* and *Sacciolepis africana* on less deeply inundated sites. The peripheral areas, where inundation is less than 40 cm and which are only briefly flooded, carry many graminaceous species, including *Acrocerus macrum*, *Heteropogon contortus*, *Hyparrhenia* spp., and *Vetiveria nigritana*, with *Loudetia simplex* and *Themeda triandra* on the very margins. Little groves of *Aeschynomene elaphroxylon* occur on isolated and elevated sandy patches along the river, and often these are accompanied around their outer, lower, margins by *Hibiscus diversifolius* which may be deeply inundated at high water. Patches of swamp forest typical of the interface between the Guineo-Congolese region and the Zambezian region, comprising *Aporrhiza nitida*, *Ficus congensis*, *Garcinia smeathmannii*, *Syzygium* spp., *Uapaca guineensis* and *Xylopia* spp. occur in some permanently wet sites along rivers and streams. Gallery forests containing *Chlorophora excelsa*, *Khaya nyasica* and *Parkia filicoidea* occupy river banks subject only to shallow and very temporary inundation upstream. *Brachystegia-Julbernardia* woodland covers much of the surrounding, unflooded country, on sandy-loam soils, but within this woodland there are numerous large dambos, often containing patches of mushitu, i.e. swampy evergreen forest.

Wetland Fauna: The fish fauna of the Luapula between Lakes Mweru and Bangweulu has both Zambezian and Zairean affinities. It is an isolated fauna, being cut off from the Zambezi system by the watersheds along the Zambia/Zaire border, and from the Upper Lualaba River by two sets of rapids

and a dam on the Luvua River below Lake Mweru. Of 120 species so far identified, 33 are endemic to the Luapula system (Poll, 1963). The lungfish, *Protopterus annectens brieri*, occurs in the associated riverine swamps and floodplains, together with *Nothobranchius taeniopygus*. Many species of fish from Lake Mweru migrate up the Luapula to spawn.

Frog populations in the swamps reach prodigious sizes, the animals falling prey to a variety of fish, snakes and birds. Reptiles found in the system include the snakes

Natriciteres olivacea, *Naja melanoleuca*, *Philothamnus irregularis*, *Psaminophis sibilans* and *Python sebae*. Arboreal species in the swamp and gallery forest are *Dispholidus typus*, *Dasypeltis scabra*, *Philothamnus semivariatus*, *Thelotornis kirtlandii* and possibly *Dendroaspis angusticeps*. The water monitor, *Varanus exanthematicus angolensis*, occurs in the swamps, and there are two terrapins, *Pelomedusa subrufa* and *Pelusios subniger*. The avifauna is typical of that found in association with floodplains, lakes and reedbeds, and is very similar to that of Lake Mweru. *Hippopotamus amphibius* and *Kobus leche leche* occur in the swamps of the lower floodplain. Other species visiting the area are *Alcelaphus lichtensteini*, *Hippotragus equinus*, *H. niger*, *Kobus ellipsiprymnus*, *K. vardoni*, *Taurotragus oryx*, *Tragelaphus scriptus*, while *Loxodonta africana*, *Redunca arundinum* and *Syncerus caffer* are found in the swampy regions along the rivers. *Cercopithecus ascanius katangae* and *C. mitis opisthostictus* are arboreal species in the riparian forests, while *Potamochoerus porcus* and *Phacochoerus aethiopicus* frequent the fringing woodland. Among small mammals, *Aonyx capensis*, *Atilax paludinosus*, *Lutra maculicollis*, and the rodents *Dasymys incomtus*, *Pellonzyus fallax* and *Thryonomys swinderianus* occur in the swamps.

Human Impact & Utilization: The area is virtually undeveloped, but some 150 000 persons live in the region. There is no mining nor manufacturing, and tourism has not yet developed. Outside the small and widely separated towns there are few villages. Small scale agriculture takes place on the floodplains, with cassava, millet, maize, groundnuts and sweet potatoes the chief crops. Fishing is locally intensive along the lower Luapula and catches have exceeded 5000 tonnes/yr. A substantial proportion of the annual catch is sent south to the railway and copperbelt towns. The bulk of the catch comprises *Oreochromis macrochir*, with some *Serranochromis* and *Tylochromis* spp., and much smaller quantities of *Alestes*, *Auschenoglanis*, *Clarias*, *Gnathognomus* and *Synodontis*. A motor boat service for passengers and cargo operates with a fortnightly schedule between Kasenga, nearly 150 km upriver, and Pweto at the northern end of Lake Mweru.

Conservation Status: Unprotected.

(d) Lake Tshangalele & the Lufira River

Country: Zaire

Coordinates: 9°00'-13°13'S/26°40'-27°57'E

Area: c. 400 000 ha (total wetland in system)

Altitude: 700-1100 m asl

Nearest Towns: Likasi (20 km W); Lubumbashi (80 km S)

General: The Lufira River has two sources (11°34'S/26°29'E and 11°52'S/26°52'E) to the west of Lubumbashi (Elizabethville), in both places rising in swampy areas. It flows from the headwater confluence, again flanked by a series of swamps, north to Lake Tshangalele (10°45' - 11°00' S/26°56'-27°16'E), one of the two major reservoirs in Shaba. Thereafter it flows north, receiving, at a point 10°30'S/27°30'E on the right bank near Kienge, a major tributary which also drains a swampy valley. Then the Lufira meanders NW across the floor of a large triangular depression, which has its apex at Kienge, and its base oriented SW-NE along the escarpment of the Manika Plateau. The triangular depression is 160 km wide at the base, and 130 km long from base to apex, thus having an area close to 10 400 km². Much of this area is of low relief. Numerous tributary streams flow down from the Kundelungu Mountains which form the eastern side of the triangle, while 3 major tributaries cross the broadest part of the depression parallel to the Manika Escarpment, having confluences just above the Lufira Rapids (9°31'S/27°02'E). From here, close to the base of the triangle, the Lufira has cut a much steeper sided valley through the Manika Plateau whence it flows to a junction with the Lualaba River 20 km north of Lake Upemba.

Lake Tshangalele is roughly rectangular in shape, some 25 km long and 15 km wide, with a narrow arm (5x15 km) pointing NE, from the tip of which it drains. It has an open water area of approximately 36 250 ha, approximately 1000 m asl. The area of wetland in the valleys of the Lufira and its tributaries north of Lake Tshangalele probably exceeds 350 000 ha.

Wetlands accompany the Lufira almost all the way from Kienge to the Lualaba, a distance of 275 km in a straight line, but possibly 440 km along river. Riparian reed and papyrus swamps, and flooded gallery forest, occupy sections of the river banks. The river and its swamps are largely confined to the eastern side of the triangular depression, along the line of the Kundelungu Mountains, but wetlands also spread along the base of the triangle, adjacent to the Manika Escarpment, along the courses of tributaries, such as the Dikuluwe. Towards the confluence of these two streams, several deeply

inundated areas of up to 3600 ha, lie away from the rivers, with less deeply inundated land closer. A chain of almost 100 recent oxbow lakes, situated to the west of the Dikuluwe River, indicates a former course. Another cluster north of the Lufira, below the confluence of the two streams, indicates that that river too has recently changed its course on the flat valley floor. Some of the lakes are 15-18 km long and 200 m wide, while others are just 200 m long and 50 m wide. Tracts of inundated land reach 17 km in width across the Lufira in places, and up to 9 km across the Dikuluwe. Where the Lufira traverses the narrow pass through the highlands of the Manika Plateau, swamps are much less extensive, but they expand again on the far side of the gorge, in the Upemba region.

Wetland Flora & Fauna: The flora and fauna of the Lufira system is similar to that of the Upper Lualaba/Upemba Lake System dealt with in section 3e.

Human Impact & Utilisation: There are fishing villages along the Lufira Floodplain, cattle are grazed in the region, and there is small scale agriculture. Fires often burn into the wetlands in the dry season.

Conservation Status: Unprotected, except for the lower part of the Lufira River immediately above its confluence with the Lualaba.

(e) Lake Del Commune

Country: Zaire

Coordinates: 10°27' -10°55' S/25°24' -25°51'E

Area: c. 60 000 ha

Altitude: c. 1100 m asl

Nearest Towns: Kolwezi (23 km W); Lubumbashi (200 km SE)

General: The Lualaba (Zaire) River rises at a point approximately 11°52'S/26°25'E close to the Zambian border, and incidently, some way south of the source of the Zambezi, 240 km to the WNW. The Lualaba at first flows WNW, parallel to the border, before swinging north to enter the impoundment of Lake Delcommune. Some land along the river is swampy, also land along the border which follows the watershed between the Zaire and Zambezi Basins. Then, other swamps occur around parts of Lake Delcommune, the area having been a wetland prior to impoundment.

Wetland Flora & Fauna: The lake has become an important site for aquatic birds and has been stocked with fish. A large proportion of the species described for the Upemba Lake System (next section) are present. The borderland swamps are mostly grass and sedge filled dambos, draining sluggishly to small streams, which may support swamps containing bushy

species along their courses, once they have become entrenched in distinct valleys. The riverine swamps are dominated by *Phragmites mauritianus* and its typical associates, but *Cyperus papyrus* occurs in the valley. Floodplain grasses similar to those described for the Luapula are also present, and there is some gallery forest, also of composition similar to that on the Luapula.

Human Impact & Utilisation: The lake is artificial and its creation destroyed most of an existing wetland.

Conservation Status: The lake and its immediate environs are afforded a degree of protection as a Natural Water Reserve.

(f) The Upemba Lakes & The Upper Lualaba River

Country: Zaire

Coordinates: 4°00'-10°00' S/25°20' -28°45' E

Area: c. 1 444 000 ha (total wetland on Lualaba System in region)

Altitude: 500-650 m asl

Nearest Towns: Kibombo (at N end); Bukama (at S end)

The Upemba Lakes: This section deals with wetlands on the Lualaba River between Lake Delcommune and Kibombo (4°00'S), a straight line distance of 750 km. Some 40 km after leaving Lake Delcommune the Lualaba enters the broad trough-like Kamolondo Depression, a graben, 100 km wide and 400 km long, oriented SW-NE, between the Manika Plateau on the east and the Hakansson Mountains on the west. The highlands of the Manika Plateau reach 1889 m asl, but the Hakansson Mountains attain heights of just over 1200 m asl. The floor of the trough is 1000 m asl at its SW end, and slopes down quite abruptly to 610 m, at which point it flattens and the Upemba Lakes and Marshes begin. The Upemba System comprises about 50 shallow lakes, the principal ones being, from south to north, Lakes Kabwe, Kabele, Sangwe, Tungwe, Malenda, Upemba, Kisale, Niangwe, Zimbambo, Kibala and Kabamba. These lakes extend along the trough for 225 km, in a belt up to 55 km wide, with a mean width of 37 km. They are set in a continuous belt of swamps, and are filled by the overflowing of the river, which winds through the swamps and between the lakes, communicating with the majority through shallow channels which are often hidden by the dense vegetation. However, it flows through Lakes Kabwe and Kisale, which are thus expansions of the main river bed. In total there are about 800 000 ha of wetland in the trough, and a further 79 000 ha immediately to the west on the Lululwe, Kilubi and Lovoi Rivers, between 8°-9°S and 24°50'-25°40'E. These latter swamps are typical riparian swamps which follow the rivers in belts up to 7 km wide for distances of up to 60 km. These swamps drain into the Lualaba via the Lovoi River, which reaches a confluence

between Lakes Kisale and Zimbambo. According to Welcomme (1979) the permanently inundated part of the Kamolondo Depression extends to about 704 000 ha, while in the wet season the flood covers about 1 184 000 ha.

Lake Upemba is the largest of the lakes, situated between 8°32'-8°49'S/26°13'-26°30'E. It has maximum open water dimensions of 40x20 km, and some 53 000 ha of open water in contracted state. However, the lake basin is over 70 km long, the northern half being practically occluded by vegetation. In profile the basin is very shallow, with a maximum measured depth of 3.2 m in November, at the end of the dry season. The bottom is covered by soft black mud and much plant debris.

The Upper Lualaba: Having left the Upemba lakes, the Lualaba, after a few kilometres, again enters a swampy belt extending 80 km along the river, with another cluster of small lakes between 6°55'-7°15'S, the largest of these being Lakes Kittongola and Towe. The river flows almost due north in this sector, and indeed does so all the way to Kongolo (5°20'S/27°00'E), traversing a very flat plateau and picking up two important tributaries on the east bank en route. These are the Luvua River which drains Lake Mweru and the Bangweulu System, and the Lukuga River which drains Lake Tanganyika. The river then loses height in traversing two sets of rapids below Kangolo, and then receives the Luama River on the east bank, before veering northwest to reach Kibombo on the parallel 4°S. Here, extending many kilometres northwards, the west bank is again swampy. Altogether 14 major tributaries enter the Lualaba between Lake Kabamba and Kibombo, but those of the east bank are more important in terms of volumetric discharge, rising as they do in the very wet mountains along the eastern border.

Another extensive wetland system occurs in the headwater regions of the Luama River. This stream has 5 sources in the mountains, two rising at altitudes over 2000 m. The river descends 3 waterfalls and several minor rapids in its lower course, but upstream of Pene Mende (4°18'S/28°11'E), it drains a flat swampy valley, the head of which bifurcates, with a branch leading NE. A tributary, coming down this much narrower valley, drains valley floor swamps right back to its source near Fizi (4°18'S/28°56'E). In their entirety, the Luama Swamps accompany the river and its tributaries for 130 km and comprise about 60 000 ha of wetland.

Climate: Mean annual rainfall over the Upemba Lakes is 1000 mm, with December the wettest month, when falls are in the vicinity of 170-180 mm. The dry season lasts for 155-165 days. Mean incident radiation is 166 Kcal/cm²/yr, and the system enjoys 2400-2500 hours sunshine/yr, with July the sunniest month (c. 395 hours) and January the most overcast month (c. 130 hours). Mean annual temperature is 24.4°C; the September mean is

27°C, with mean monthly maxima and minima of 36 and 19°C, and the corresponding June figures are 23, 33 and 14°C. Rainfall increases progressively along the Lualaba, north of the Kamolondo Depression, reaching 1400 mm in the vicinity of Kasongo (4°30'S) and 1700 mm at Kindu (3°00'S). Between this point and Kisangani, where the middle course of the Zaire River begins, the Lualaba flows due north through a very wet zone, where over 2000 mm of rain falls each year and there is no distinct dry season.

Hydrology & Water Quality: In the Upemba System, the waters of the Lualaba are high from February-April and low from August-October. The mean fluctuation in water level at Bukama, at the southern end of the system is 2.8 m, with minimum depths of 3 m and maximum depths of 5.8 m. At Maka the change in level is only 1.1 m over the course of a year, with a low level of 1.9 m and a maximum of 3 m. Lake Upemba is high from March-June and low from October-January. The depression is exorheic and drains from the north via the Lualaba.

The waters of the Upemba Lakes are warm with mean surface temperatures close to 23°C in July and 33°C in November. The lakes are polymictic and even bottom temperatures reach 31°C in November. The pH range is 6.4-8.0 and the waters may be brown, or yellowy-green in colour.

Wetland Flora: The Upemba Lake/Swamp system presents vistas of tall herbaceous swamps, dominated either by *Cyperus papyrus* or by *Typha domingensis*, but with *Pycnus mundtii* and *Paspalidium geminatum* common on the sides of water courses. All these species line the Lualaba River and the numerous lakes, and huge rotting floating mats of *Cyperus papyrus*, some of which reach 10-15 ha in extent, may detach from the banks and begin to drift on the lakes. This species has, among its lower growing aquatic associates, *Cyclosorus striatus*, *Impatiens* cf. *kasaiensis*, *Ipomoea aquatica*, *Panicum repens*, *Polygonum salicifolium* and *Vossia cuspidata*, and these may all be found on or in the rafts. Other small rafts are found to be composed of *Pycnus* and *Paspalidium*. Little patches of swamp woodland, comprising almost exclusively *Aeschynomene elaphroxylon* and *Hibiscus diversifolius*, occur on abandoned levees and other elevated sandy sites, which are inundated to depths of 40-60 cm at high water. These support a dense avifauna and are often whitened by the guano of roosting birds. The open waters may become covered by waterlilies, *Nymphaea caerulea*, *N. lotus* and *Nymphoides indica*, together with *Lemna* sp., *Pistia stratiotes* and *Trapa ratans*.

As the Lualaba flows north the surrounding savannas become more dense until eventually the canopy closes and rises, so that hundreds of kilometres before the river crosses the equator it is enclosed by high equatorial rain forest. The deciduous, and then evergreen gallery forests of the savanna

zones become progressively less distinct, physiognomically if not floristically, as finally the galleries merge with the rain forest. The river broadens and its banks become sandier, and the forest front along the river is festooned with lianes. The flora of the riverine forest in this most northerly part of the region is similar to that described in the next section, Wetlands of the Central Zaire Basin.

Wetland Fauna: The fish fauna of the upper Lualaba comprises 141 species, among the most noteworthy of which are the two lungfishes *Protopterus aethiopicus congicus* and *P. annectens brieni*, several species of *Polypterus* (*P. birchir katangae*, *P. endlicheri congicus*, *P. ornatipinnis* and *P. senegalus meridionalis*), and *Ctenopoma ctenotis*, *Ichthyborus besse*, *Oreochromis upembae* and *Tetraodon mbu*. According to Poll (1976) 14 species are endemic to the Upemba system. A number of Upemba species spawn near the sand beaches at low water when they suffer intense predation, e.g. *Clarias* sp., *Labeo annectens*, *Oreochromis niloticus upembae*, *Synodontis notatus* and *S. pleurops*.

The frog and toad populations in the Upemba district are prodigious. Over 40 amphibians have been recognised in the Upemba National Park, 34 of which are known to occur in the wetlands. Some species are reputed to be endemic to the Kamolondo Depression, e.g. *Afrivalus fulvovittatus upembae* (a reed frog) and *Phrynobatrachus cryptotis*. *Hemiscus wittei* is common.

Crocodylus cataphractus is quite abundant but *C. niloticus* is less so. The water monitors *Varanus exanthematicus* and *V. niloticus* are both present, as are several terrapins. Other aquatic or semi-aquatic reptiles include *Amphisbaena quadrifrons capensis*, *Aparallactus capensis punctolineatus*, *Boulengerina annulata*, *Dromophis lineatus*, *Monopeltis scalper gerardi*, *Natriciteres olivacea*, *Naja melanoleuca*, *Philothamnus irregularis*, *Psammophis olivacea* and *Python sebae*. Among the arboreal species of gallery forests *Dasyptis scabra*, *Philothamnus semivariatus* and *Thelotornis kirtlandii* are most common.

The avifauna of the wetlands is very similar to that of the Bangweulu Basin in Zambia, and to the Lake Mweru/Luapula Floodplain fauna. It includes most of the widespread species listed in section 1, Bas-Zaire, together with *Actophilornis africana*, *Ardea goliath*, *Balaeniceps rex*, *Butorides rufiventris*, *Dendrocygna viduata*, *Grus carunculatus*, *Larus cirrocephalus*, *Limnocorax flavirostra*, *Muscicapa aquatica*, *Pelecanus rufescens*, *Plectropterus gambensis*, *Ploceus pelzelni*, *Porphyryla alleni* and *Sarkidiornis melanotos*. Palaearctic migrants include *Acrocephalus schoenobaenus*, *Chlidonias leucoptera*, *Larus fuscus*, *Motacilla flava*, *Riparia riparia* and *Sterna hirundo*.

Mammals associated with wetlands throughout this particular region include *Aonyx capensis*, *Atilax paludinosus*, *Cercopithecus mitis opisthostictus*, *Dasymys incommutus*, *Hippopotamus amphibius*, *Kobus ellipsiprymnus*, *K. leche*, *Leptailurus serval*, *Loxodonta africana*, *Potamochoerus porcus*, *Potamogale velox* and *Syncerus caffer*. Other species are particularly associated with the papyrus and *Typha* swamps, e.g. *Pellomys fallax*, *Tragelaphus spekei* and *Thryonomys swinderianus*, while yet others frequent the gallery forests of the Lualaba and its tributaries. Among these the following can be cited: *Cephalophus monticola*, *C. sylvicultor*, *Cercocebus aterrimus*, *Colobus badius foal*, *C. polykomos prigoginei*, *Felis aurata*, *Galago demidovii*, *Nandinia binotata*, *Pan paniscus* and *Tragelaphus scriptus*.

Human Impact & Utilisation: The southern part of the region is comparatively densely populated. The large towns of Lubumbashi, Likasi, Tenke, Kolwezi, Lubudi and Bukama are strung out from SE to NW across the southern end of the region, but the populations of these centres exert little influence on the wetlands immediately to the north, except that of Bukama at the southern end of the Upemba System. Within the Kamolondo Depression population density increases from south to north, but the only centre is Malemba-Nkulu, in the region of which there were 175 388 inhabitants in 1975. There are neither manufacturing industries nor tourism. Fishing villages occur along the Lufira, and around the northern, unprotected lakes of parts of the Upemba System. Fishing in the depression is locally intense. The total catch for 1957 was in excess of 22 000 tonnes, but the figure has declined since then. Nevertheless, the 15 424 tonnes catch of 1981 was the lowest for some years. The area is the chief fish producing centre for Shaba and most of the annual catch is exported to the afore-mentioned towns, or to Kasai. The commercial fishing centres are Maka, Kialo, Nyonga, Kalombe, Kikondja, Masango, Malemba-Nkulu, Kabala, and Mulongo.

The Lualaba River is navigable between Bukama and Kongolo, a distance of some 650 km, but in 1938 the railway line between Kongolo and Kabalo was opened, and since then regular commercial river traffic has terminated at Kabalo. Before 1956 the annual cargo haul downstream was 60 000-80 000 tonnes, while coming upstream, it was about 50 000 tonnes, with about 8000 passengers being carried in each direction. In 1956 a rail link was inaugurated between Kabalo and Kamina (107 km NW of Bukama), after which river transport rapidly diminished in importance, but there is still traffic between Malemba-Nkulu, in the centre of the Upemba System, and Kabalo. In the southern part of the Upemba System, Bukama and Malemba-Nkulu, the maintenance of a navigable channel

through the papyrus has been virtually abandoned. In the dry season burning of peripheral wetland areas, in the Kamolondo Depression and Lufira Valley, often causes fires in the wetlands.

Conservation Status: About half of the Upemba Lake System, comprising all the local biotypes, is totally protected in the Upemba National Park, established as an integral nature reserve. The protected area includes Lakes Kabwe, Kabele, Sangwe, Malenda, Tungwe, Upemba and Kisale, and 180 km of the Lufira River, upstream from its confluence and through the gorge in the Manika Plateau, almost to Lufira Falls.

4. Wetlands of the Central Zaire Basin

Country: Zaire

Co-ordinates of Region: 3°00'N-4°00'S/16°00'-26°00'E

Area of Region: c. 774 562 km²

Altitudinal Range: 310-500 m asl

General: The central depression of the Zaire Basin is largely covered by high tropical rain forest with a canopy often over 45 m high. This is the largest expanse of this type of vegetation in Africa, and the numerous rivers which drain it are essentially forest rivers; they are all slow flowing, the broader ones with lacustrine characteristics. The area is flat or very gently undulating, with a general inclination towards the west.

(a) Riverine Swamps & Forests

Country: Zaire

General: The Kasai River (known as the Kwa in its lowest course), always over 2 km wide and in one place reaching 8 km in width, skirts the southern edge of the depression between Ilebo (= Port Francqui, 4°20'S/20°35'E) and its confluence with the Zaire River (3°10'S/16°12'E), collecting the water of all the streams flowing down from Angola across Kasai and southern Bandundu Provinces. It also drains the southern part of the central depression, receiving the waters of the Lukenie River, together with those collected into Lake Mai Ndombe, through its major north bank tributary, the Fimi River.

Low plateau land, at an elevation of about 500 m, forms the eastern boundary of the depression and another block of elevated land between the Zaire and Oubangui Rivers forms the northern boundary. The Zaire River traverses the northern side of the depression, flowing from east to west in an island studded bed. This reaches 17 km in width where Sumba Island (90 km long) interrupts its course (1°44'N/19°33'E). Along the north of the depression the Zaire River receives, on its north bank, numerous tributaries draining the elevated land between it and the

Oubangui, which here flows in parallel farther north. In passing downstream from Kisangani the principal tributaries are the Tshopo, Lindi, Aruwimi, Itimbiri (which forms a substantial delta in the Zaire River, so sluggish is the current) and Mongola Rivers. Large swamp forests and raphiales cover the lower valley floors of all these tributaries, e.g. there are at least 150 000 ha of swamp in the Itimbiri River system, including a solid block of over 54 000 ha which occludes the lower valley floor with a mean width of 9 km over a 60 km stretch, immediately above its delta. All the streams draining into the Itimbiri carry swamp forest almost to their sources, and such is the case for all the other north bank tributaries.

The entire plateau area between the Zaire and Oubangui Rivers is scored by the strip swamps of riverine wetlands, always comprising 5-10% of the land surface, but 20-40% to the south of Gemena (3°13'N/19°48'E) in the upper reaches of the Mongala and Giri Rivers, and to the west below the confluence of the Lua Dekere and Lua Vindu Rivers. In the northeastern borderlands all streams in the catchments of the Mbomou and Uele Rivers are swampy, and after their confluence, to form the Oubangui at Yacoma (4°05'N/22°22'E), both its course and that of its tributaries are swampy. The bed of the Oubangui forms the border with the Central African Republic, and thereafter, that with Congo, and its most important tributaries enter from those countries.

In the central part of the depression, south of the Zaire River, all the major streams, with the exception of the Lomami, flow roughly E-W again parallel to the Zaire, and many carry substantial areas of swamp forest in their shallow valleys, e.g. swamps occur upstream from the confluence of both the Lulonga and Ruki Rivers with the Zaire River. Both rivers bifurcate into lesser tributary streams, and on these, swamps are equally well developed. The Ruki, for example, divides to form the Momboyo and the Busira. Swamps occur on both these rivers above their confluence to form the Ruki. There is a block of 25 000 ha on the Momboyo, and another of 55 000 ha on the Busira, between 19°00' and 19°27'E. Farther upstream, near Boende, the Busira River divides at the confluence of the Tshuapa and Lomela Rivers. This is in the wet heart of the central depression where mean annual rainfall exceeds 2000 mm/yr and there is no dry season. Both the Tshuapa and Lomela carry broad swamp belts along their banks. There is a block of permanent swamp forest along 165 km of the Tshuapa from 20°33' to 22°00'E, covering about 160 000 ha, and another of 88 000 ha on the Lomela from 20°35' to 21°30'E, through which the river meanders for 110 km, and farther up this river, yet another block of 46 500 ha between 21°50' and 22°18'E. Land subject to inundation accounts for 20-25% of the total land surface throughout parts of the Tshuapa catchment. By contrast to the foregoing rivers, the Lomami flows from south to north, parallel with the Lualaba section of the Zaire River, and joins it after that river has

swung west. The confluence of the two rivers is 125 km downstream from Kisangani. Extensive swamps occur in the lower valley of the Lomami, and on the bank of the Zaire River opposite the Lomami mouth.

At a longitude of 20°E the Zaire River swings SW to Malebo Pool and in this section, along its left bank, collects all the tributaries draining the central depression, including the Ruki and finally, the Kasai. Throughout their courses the Kasai, Oubangui and Zaire Rivers flow over a broad alluvial plain, and although by no means continuous, behind their levees are seasonally flooded forests which extend away from the rivers on deep alluvium for distances of up to 50 km. Seasonally flooded forest also covers or fringes many islands in the river, and at the riverside, on low islands in midstream and in depressions in the seasonally flooded forests there are patches of permanent swamp forest. On the south bank there is a block of swamp forest, covering 68 000 ha just west of Kisangani and a major block along 250 km of river frontage from 18°45' to 21°40'E, covering some 425 000 ha, opposite Sumba Island. Here, the land is traversed by anastomosing channels, parallel with the main river, in what is effectively an inland delta. However, the largest expanse of permanent swamp forest occurs at the western side of the depression, where the streams draining the central part flow into the Zaire River. Here, a virtually continuous block of permanent and seasonally flooded forest extends along the left bank for 250 km below the Ruki River mouth near Mbandaka (= Coquilhatville, 0°03'N/18°28'E), and inland for 275 km, covering about 5 000 000 ha and encompassing Lakes Tumba and Mai Ndombe. Immediately south of this, opposite the mouth of the Alima River which enters from Congo, another swampy block 70 km wide and up to 30 km deep covers over 190 000 ha along the Sangasi Itoka and other small tributary streams.

Throughout the central depression, away from areas subject to inundation as a consequence of rivers overflowing their banks, rain swamps develop in depressions in which the water table is close to the surface and which may be intermittently flooded by rain.

On its right bank the Zaire River receives the Oubangui, which has also turned sharply south to form the border with Congo for 500 km, and to meet the Zaire River at point 0°27'S/17°47'E. An enormous area of permanent swamp exists in the triangle of low flat land between them. This measures 375 km along the perpendicular from base to apex (at the confluence) and 165 km across the base in the north and comprises some 3 000 000 ha of permanently waterlogged or flooded forest. The Giri River, rising near Kungu (2°50'N/19°19'E) almost bisects this triangle of land, providing a trench roughly along the perpendicular, and flowing into the Oubangui just before that river enters the Zaire River. Numerous channels, up to 50 km long, connect

the Giri and Zaire Rivers through the swamps, along the eastern side of the triangle. At the confluence with the Oubangui, the Zaire River is fully 15 km wide.

Wetland Flora

The unflooded parts in the west and centre of the great depression are covered by evergreen forest, but on the elevated lands bordering it in the far northeast and southeast, where rainfall is less, the forest becomes semi-deciduous in nature. In all cases, where the forests are undisturbed, the wetlands are dominated by arborescent species, and the swamp forests tend to grade into terrestrial forests through extensive transition zones in consequence of the flatness of the land. In some places, floating grass swamps occur along the rivers in areas of deep semi-permanent inundation, with swamp forests farther away from the rivers on less deeply inundated ground.

Riparian & Floodplain Associations: In the north of the region, between the Oubangui and Zaire Rivers, where agriculture is most intense, *Thalia welwitschii* (Marantaceae) swamps become established along rivers where the gallery forest has been destroyed. The existence of this vegetation depends upon a variable water level and a fairly swift current, at least in the wet season. *Thalia* is an obligate heliophyte, and these swamps, which contain few associates, quickly deteriorate if trees reappear. If the water levels are lower and less variable, and the water movement is sluggish, *Cyrtospenna senegalense* becomes established and is usually quickly succeeded by arborescent species.

Other secondary associations occur in the higher country between the Zaire and Oubangui Rivers, between 500-700 m asl. Here, *Loudetia phragmitoides* swamps occur along the edges of gallery forests on poorly drained soils. These swamps include such other species as *Cyclosorus striatus*, *Cyperus halpan* (= *C. halpan*), *Eulophia caricifolia*, *Ludwigia africana*, *Lycopodium cernuum*, *Sauvagesia erecta* and *Torenia parviflora*. They occur where the water table is always high and periodic flooding occurs, where as on better drained soils, where fires frequently occur, *Imperata cylindrica* becomes dominant.

Also in this region, where pools and quiet backwaters in the narrow parts of rivers are heavily shaded by gallery forest, a *Nymphaea lotus-Utriculara thoningii* community develops. This is floristically impoverished by the low light intensities. By contrast, where the canopy is open there is a much richer vegetation. Provided that water movement is minimal, water levels seem unimportant and here, *Nymphaea maculata* is dominant, while *Eleocharis acutangula*, *Fuirena stricta*, *Hydrocharis chevalieri* and *Sabicea africana* are the most common of a dozen or more associates.

Pioneer Associations: The pioneer species on sandy banks along and in the large rivers of the central depression is *Panicum repens*, which is soon joined by *Acroceras zizanoides*, *Cyperus erectus*, *C. nzaculatus* and *Hemarthria natans*, leading finally to a sward of *Cynodon dactylon* where inundation is infrequent. By contrast on mudbanks, the pioneers are *Basilicum polystachyon*, *Commelina diffusa*, *Eclipta prostrata*, *Ipomoea reptans* and *Ludwigia repens*. Meadows of aquatic grasses develop in deep water along the banks of backwaters, and here *Echinochloa pyramidalis*, *E. stagnina* and *Vossia cuspidata* are the most frequently encountered species, but in shallower places *Phragmites mauritianus* or *Cyperus papyrus* may cover extensive areas in monospecific stands. Little depressions on islands in the river are colonised by *Cyperus longibracteatus* and *Rhynchospora corymbosa* when they fill up, usually with some persistent *Echinochloa pyramidalis*. Open surfaces in quiet backwaters tend to be covered by *Lemna paucicostata*, *Nymphaea caerulea*, *N. lotus*, *Pistia stratiotes* and *Utricularia* spp., but comparatively recently *Eichhornia crassipes* has been introduced and tends to dominate this habitat, and also to invade the areas normally supporting floating grasses. It has become a serious threat to navigation in certain localities. Steep sandy river banks and cliffs are covered at water level by plaques of *Marchantia chevalieri*, and above the water by a tracery of ferns dominated by *Dicranopteris linearis*. On any slips or shelves however, and on the tops of the cliffs, the forest vegetation quickly takes root, in particular *Anthocleista nobilis*, *Barteria nigritiana*, *Caloncoba welwitschii*, *Vernonia conferta* and occasionally, *Alchornea cordifolia*.

As they become more elevated, islands are colonised by woody species, first by single trees, or little clumps of *Alchornea cordifolia* with *Bridelia micrantha*, *Ficus mucuso* and *Spondianthus preussii*, often with abundant *Mimosa pigra*. This pioneering woody vegetation is quickly entangled by creepers, and *Alchornea* is usually dominant in the early stages of the succession. However, in the east of the region at least, a tall forest of *Lannea welwitschii*, with *Ceiba thoningii*, *Ficus mucuso*, *Oxystigma buchholzii*, *Pseudospondias microcarpa* and *Spondianthus preussii* quickly replaces the *Alchornea* association. Occasionally *Elaeis guineensis* may be encountered in this vegetation, and the understorey becomes moderately thin with *Leptonychia batangensis* the most characteristic species. At the upstream ends of islands, erosion during high floods may cause trees to be uprooted, and when the waters subside the gaps so formed tend to be filled by stands of the coarse herb *Costus lucanusianus*. Swampy depressions on the islands and along the river banks are covered by a forest containing *Albizia laurentii*, *Chrysobalanus atocorensis*, *Coffea congensis*, *Irvingia smithii*, *Uapaca heudelotii* and *Trichelia retusa*, and there may be extensive

monospecific stands of *Uapaca guineensis*, both on the islands and along the mainland riverbanks. The strong currents which arise during the periods of high flood in the main river channels seem to inhibit the development of other seral stages.

In the north of the region, between the Zaire and Oubangui Rivers, the banks of tributaries subject to regular inundation are colonised by *Alchornea cordifolia*, *Macaranga saccifera* and *Raphia laurentii*, all heliophilic species. This tends to be succeeded by *Mitragyna stipulosa* forest described below, but the floodplain forests on the valley floors of these rivers usually become separated from the water in the river channel proper, by a narrow strip of riparian fringe forest. This fringe forest grows where inundation is semi-permanent, and it contains characteristically, an abundance of *Uapaca heudelotii* with *Antidesma leptobryum*, *Embellia retusa*, *Flacourtia* sp., *Hymenocardia heudelotii*, *Parinari congensis*, *Trichelia retusa* and *Uvaria laurentii* as common associates.

Floodplain Forests: Behind the riparian strips periodically inundated forests occur. Several types of riverine swamp forest are encountered along tributary rivers, differing quite markedly in their physiognomy and depending for their existence upon different soil types. Floristically these forests are quite diverse, varying in composition from place to place across the vast central depression and often they are mosaics of different associations. However, to generalise, on muddy soils along watercourses, where inundation is periodic, but deep and frequent, and where the water flows only very slowly, the forest is usually dominated by *Mitragyna stipulosa*.

Mitragyna is found everywhere, but its associates vary. Among the most widespread are *Alstonia congensis*, *Anthocleista liebrechtsiana*, *Anthonotha pynaertii*, *Baikiaea insignis*, *Berlinia bruneelii*, *Brazzeia congoensis*, *Crotonogyne giorgii*, *C. poggei*, *Dialium pachyphyllum*, *Dichostemma glaucescens*, *Eriocoelum microspermum*, *Macaranga* sp., *Nauclea diderrichii*, *N. pobeguinii*, *Ouratea arnoldiana*, *Parinari glabra*, *Syzygium gillettii*, *S. guineense* ssp. *huillense*, *Uapaca heudelotii*, *Voacanga thouarsii*, *Xylopia aethiopica* and *X. rubescens*. *Ancistrophyllum secundiflorum*, *Calanzus deeratus*, *Eremospatha* spp. and *Popowia lucidula* are scandent species. *Cyrtosperma senegalense* and *Marantochloa congensis* are common in the understorey. The canopy of this type of forest reaches 30-40 m.

In places where the water moves quite swiftly, and where inundation is less prolonged and the soils are sandy, the forests are dominated by *Guibourtia deineusei*. The forest is dense and the canopy reaches or exceeds 30 m, but the under-storey is sparse. Common associates in this forest type are *Brazzeia*

eetveldeana, *Casearia congensis*, *Cleistanthus libericus*, *Coffea congensis*, *CreMASpora triflora*, *Dialium reygaertii*, *Drypetes angustifolia*, *Garcinia pynaertii*, *Hymenocardia heudelotii*, *Memycylon* sp . , *Mimusops warneckei*, *Mapania bieleri* (Cyperaceae), *Morelia senegalensis*, *Popowia lucidula*, *Salacia pallescens*, *Scytopetalum pierreanum* and *Xylopia katangensis*.

Along the lower courses of tributaries to the Zaire River, in the east of the depression, the lowest parts of the valley floors, which are almost permanently flooded but constantly flushed by moving water, tend to be covered by a forest distinguished by an abundance of *Lasiodiscus manni*, *Raphia* spp. and *Uapaca guineensis*. On either side, in the wider valleys, strips of *Mitragyna stipulosa* forest grade into broad belts of pure *Gilbertiodendron dewevrei* forest, at higher and less frequently inundated levels. *Gilbertiodendron* forest occurs on hydromorphic soils, but is transitional to terrestrial forest, and in the north often contains a substantial proportion of *Anopyxis klaineana*.

Patches of alluvium build up away from the current on the quiet sides of meander bends in all the larger rivers, and deltas have developed where tributary streams enter quiet stretches of the Zaire River. These muddy sites are first colonised by *Alchornea cordifolia*, but this is quickly succeeded by mixed forest, leading to a stage dominated by *Alstonia congensis*, and this in turn eventually gives way to an *Entandrophragma palustre* forest. This latter species may be found in association with *Anubias affinis*, *Dichostemma glaucescens*, *Elaeis guineensis*, *Mitragyna stipulosa*, *Myrianthus scandens*, *Pycnanthus marchalianus*, *Raphia* spp., *Ricinodendron palustre*, *Sersalia palustre* and *Symphonia globulifera*, but it sometimes occurs in almost monospecific belts more than 5 km wide. This association constitutes one of the last stages of the hydrosere, preceding *Gilbertiodendron dewevrei* forest, which usually provides a transition to terrestrial rain forest.

Permanent Swamp Forests: In some shallow basins, away from the rivers, where inundation is more or less permanent and the surface water is semi-stagnant, the forest is characterised by an abundance of *Sterculia ambacensis*. In these sites the soil surface is always muddy, and most arborescent species have either tall flanged buttresses or stilt roots. The buttresses of *Sterculia anzbacensis* are narrow and plank-like, several metres tall at the base of the trunk, but often wind tortuously over the forest floor with heights of 50-100 cm for distances of up to 15 m. In this type of forest the most common associates are *Coelocaryon botryoides*, *Lasiodiscus manni*, *Mimusops warneckei*, *Pseudagrostistachys ugandensis*, *Pseudospondias microcarpa*, *Symphonia globulifera* and *Treculia*

africana.

Wetland Fauna

There is a rich fish fauna. Within the central depression, the three major rivers provide 3150 km of continuous river surface, 2-15 km wide, providing well over 2 000 000 ha of water, open to the sun and wind. On either side of the rivers there are strips of swamp forest providing, probably, a further 8 500 000 ha of seasonally aquatic habit, but throughout this area, there are permanent swamps which never drain. The myriad tributaries of these three principal rivers have a different character. They are mostly quicker flowing, and those under 50 m wide are generally shaded by the forest, with lower water temperatures. They also have narrower floodplains. The fish fauna changes across the central depression, but in any one place it is possible to distinguish different faunas in different habitats; in the open waters of the main rivers, along the banks, in the creeks, coves and meadows of aquatic vegetation, in the permanent swamps, and on the floodplains. Rapids or waterfalls isolate this giant system, situated 300-425 m asl, from the estuarine section of the river and the streams of the highland parts of the Zaire Basin.

Having said this, the fish fauna of the river is not known in any detail. Studies have been made at Malebo Pool (Poll, 1959) at the lower end of the depression, at Yangambi (0°47'N/24°24'E) far up the Zaire River (Gosse, 1963), and at Ikela (1°06'S/23°06'E) way upstream on the Tshuapa River (Matthes, 1964). Many fish leave the rivers to spawn in the forest at high water, moving back to the channels when the floods recede, but the juveniles of some species remain in the permanent swamps. The number of species found in the forests and swamps is far lower than that found in the river, and in the river the number of both individuals and species is greater along the banks than in the open waters. At Yangambi, of 43 Mormyridae identified, 38 species are found in the river, 14 in the tributaries and 6 in the swamps. Of 14 cichlids, 7 are found in the river, 6 in the tributaries and 1 in the swamps, and of 10 anabantids, 5 occur in the river, 8 in the tributaries and 3 in the swamps.

The permanent swamp dwelling fishes have accessory breathing organs since the swamp water is semi-stagnant, and the bottom layers are completely anoxic. Those so far identified are *Clarias* spp., *Clariallabes melas*, *Chanallabes apus*, *Ctenopoma fasciolatum*, *Ctenopoma* sp., *Hemichronzis bimaculatus*, *Pantodon buchholzii*, *Papyocranus* sp., *Paraophiocephalus obscurus*, *Pekatochromis ocellifer*, *Phractolaemus* sp., *Polypterus palmus*, *Protopterus aethiopicus*, *P. dolloi* and *Xenomystus nigri*, 17 species in all. The numerous high water visitors include *Hepsetus odoe*. These swamps never dry out, so that the protopterans do not aestivate as they do elsewhere in Africa.

Huge shoals of plankton feeding *Microthrissa* are pelagic in the rivers, migrating up and downstream seasonally. Small species of *Barbus* and *Clupeopetersius*, and their predators such as *Hydrocynus vittatus*, also occur in pelagic situations. Among benthic fish there are many insect or detritus feeders in the rivers, e.g. species of *Barbus*, *Chrysichthys*, *Synodontis* and *Tylochronzis*, also *Citharinus*, a mudsucker, and piscivores, including other species of *Chrysichthys*, *Mormyrops* and *Polypterus*, and species of *Labeo* and *Tetraodon* where the bottom is sandy and the current swift. Large species of *Clarias*, weighing as much as 150 kg, have been taken from deep holes on the downstream sides of islands, and here also live very large specimens of *Heterobranchus* and *Lates niloticus*, the latter attaining weights of 50 kg. *Malapterus electricus* is common throughout the system.

Two crocodiles, *Crocodylus cataphractus* and *C. niloticus*, occur in the rivers, also *Varanus exanthematicus*, *Pelomedusa* sp., *Pelusios* sp., and aquatic or semi-aquatic snakes including *Boulengerina annulata*, *Dromophis lineatus*, *Philothamnus irregularis*, *Natriciteres olivacea*, and *Python sebae*. In the trees there are other snakes, including *Dendroaspis* sp., *Dispholidus typus*, *Philothamnus* sp. and *Thelotornis kirtlandii*. The spectrum of birds is very similar to that described in section 1, Bas-Zaire.

Mammals in the system include the usual aquatic types, *Aonyx congica*, *Atilax paludinosus*, *Dasymys* sp., *Hippopotamus amphibius* and *Lutra maculicollis*, with *Osbornictis piscivora* confined to the north. Species of the swamp forests include *Cephalophus monticola*, *C. sylvicultor*, *Genetta tigrina*, *Hyenzoschus aquaticus*, *Kobus ellipsiprynzus*, *Loxodonta africana cyclotis*, *Loxodonta pumilio* (sometimes said to be another form of *L. africana cyclotis*), *Manis gigantea* (N only), *M. tetradactyla*, *Neotragus batesi* (NE only), *Syncerus caffer nanus*, *Tragelaphus scriptus* and *T. spekei*. The pygmy chimpanzee, *Pan paniscus*, is widespread though uncommon in the central depression between the Zaire, Lualaba and Kasai Rivers. It visits seasonally flooded forests during dry periods. *Potamochoerus porcus* is locally abundant, while *Phacochoerus aethiopicus* occurs in the eastern parts, but is most common east of the Lualaba and west of the Oubangui in Congo. *Felis aurata* and *Panthera pardus* are also known from the region. Many monkeys live in riverside forests, e.g. *Allenopithecus nigroviridis* (N only), *Cercocebus atterinzus*, *C. albigena*, *C. galeritus chrysogaster* (south of the Zaire River to the Lukenie and east to the Lomami), *Cercopithecus aethiops cynosurus* (S only), *C. ascanius*, *C. lhoesti* (E only) *C. nzitis maesi*, *C. stuhlmanni* (NE only), *C. mona wolfs* (W only), *C. mona elegans* (E only), *C. mona denti* (NE only), *C. neglectus*, *C.*

nictitans (NW only), *C. pogonias grayi* (N only), *Colobus badius*, *C. guereza* (N only), *C. poly-komos* and *Miopithecus talapoin* (W only). Other arboreal species include *Anomalurus beecroftii* (NE only), *A. derbianus*, *A. pusillus* (N only), *Dendrohyrax arboreus*, *Funisciurus congicus* (WC depression), *F. pyrrhopus* (N only), *Galago demidovii*, *Heliosciurus rufobrachium*, *Idiurus macrotis* (N only), *I. zenkeri* (N only) and *Zenkerella insignis* (W only).

Human Impact & Utilisation: Throughout the central depression, land which is subject to regular inundation is generally still in pristine condition, since, traditionally, it has been regarded as having no agricultural potential. However, in a number of sites adjacent to the banks of the larger rivers, where inundation is distinctly seasonal, there have been extensive local clearances for rice production. Almost all the rivers are fished, and the major streams provide the principal communication routes to the interior, linking the railheads at Kinshasa, Ilebo, Bumba and Kisangani, and providing the only viable route for cargo from Kinshasa to many major centres. The Zaire and Oubangui Rivers are also used by traffic to ports in Congo and the Central African Republic.

Conservation Status: A large area, c. 3 600 000 ha, of the southern central depression is protected in the Salonga National Park. This is in two sections, separated by a broad corridor of land. The southern section includes the watershed separating the Luilaka River in the north from the basins of the Lukenie River in the south and the Lokoro River in the west. Part of the Lomela River system is protected in the northern section. The park is very poorly explored, from the biological point of view. Access is by river and there are neither tourist facilities nor management plans. The area has been left as wilderness.

Along the northern border, the Bomu Nature Reserve lies along the south bank of the Bomu River, extending from a point about 40 km above the confluence with the Oubangui River for about 500 km to the border with Sudan. Within this reserve, in addition to the south bank of the Bomu River, which forms the border with the Central African Republic, there are the valleys of several tributary rivers including the Asa and Gwane. The far eastern section of the park is much drier than other parts of Zaire with a long dry season, during which temperatures may rise above 35°C and desiccating NE winds blow from Sudan. There are nevertheless extensive wetland areas in the reserve, including *Loudetia* and papyrus swamps and flooded gallery forests.

(b) Lake Tumba

Country: Zaire

Coordinates: 0°37' -1°00' S/17°49' -18°09' E

Area: 76 500 ha (open water)

Altitude: 325 m asl

Nearest Towns: Mbandaka (80 km NNE); Kinshasa (480 km SE)

General: The lake is shallow, increasing in depth from 3 m in the south to 8 m in the north, at the entrance to the Irebie Canal, through which it drains to the Zaire River. The banks are steep with the maximum water depths being found close to the banks. The periphery is cloaked by forest, some of which is unflooded, but much of which is seasonally or permanently inundated. In sites of deepest inundation the forest gives way to herbaceous swamp. There are several small islands in the lake, and affluent streams have formed small deltas.

Climate: The lake enjoys about 2000 hours of sunshine a year, with little variation from month to month. Total incident radiation amounts to 133 Kcal/cm²/yr. Wind speeds tend to rise from 4 km/hr in the early morning to about 8 km/hr at midday and then die back to 3 km/hr by the evening. Winds are predominantly from the south during low water periods but swing to the west during the high water periods. Occasionally there are violent storms. Mean annual rainfall is 1800 mm, with maximum intensity in October and November (200-220 mm/month) and February-April (170-200 mm/month), and a minimum in July when only 70 mm may fall. Relative humidity is 80-90% throughout the year, and evaporation from the lake is estimated as 1300 mm/yr. Mean annual temperature is 25.5°C. The mean monthly figure for March-April is also 25.5°C, with mean daily maxima and minima of 31.5 and 21.5°C. The corresponding figures for July are 24.5, 29.5 and 21°C.

Hydrology & Water Quality: The lake was formed in recent times by the obstruction of a tributary river close to the point where it discharged into the Zaire River, leading to the inundation of part of its shallow lower basin. It has several affluents draining a region of permanently and seasonally inundated forests. However, water may enter it from the Zaire River at times of high flood. Water level fluctuates by about 4 m a year, but there are also important fluctuations of the mean lake level from year to year.

The lake is unstratified and the water temperature varies between 26-33°C over the course of a year, with Secchi depths of 90-100 cm in mid-lake and c. 75 cm near the banks. The waters are humic, stained brown and acidic, with a pH range of 4.5-4.9. Salinity is low with a total mineral content of 30-35 mg/l. By contrast suspended organic matter is high, also accounting for 30-35 mg/l. Dissolved oxygen is however, relatively

abundant throughout the water column and throughout the year, there generally being 4-6 mg O₂/l, representing 50-70% saturation.

Wetland Flora: In calm coves the lake water is covered by floating mats of *Echinochloa pyramidalis* and *Panicum parviflorum*, which towards the banks merges into a bed of *Jardinea congoensis* and *J. gabonensis*, with thickets of *Cyrtosperma senegalense* and *Rhynchospora corymbosa*. This peripheral vegetation may extend out into the lake for 100 m or more, where the edges may be broken up by wave action to create free drifting masses. These, if they come to shore, start fresh colonies. Pools of open water are quite common within the meadows of floating grasses, and are sometimes partly occupied by an association of *Nymphaea lotus* and *Utricularia benjaminiana*. *Eichhornia crassipes* is sometimes dragged into the lake by boats, or enters at times of very high floods from the Zaire River, but does not become established, possibly because of the acidity of the water.

The junction of the herb zone with swamp forest on the banks is marked by the development of a shrubbery, dominated by *Dissotis segregata*. Where the bank is steep, swamp forest develops on the lakeward side of the bank, in sites only exposed at the periods of lowest water, and thus submerged up to 4 m deep at high water. The dominant tree is *Irvingia smithii*, with *Alchornea cordifolia* and *Cynometra schlechteri* as the most abundant associates. A little higher, in the zone of periodic inundation, the forest is dominated by *Guibourtia demeusei* and *Uapaca heudelotii*. Swampy banks of gentle slope are colonised by a forest of *Oubanguia laurentii*, with an abundance of climbing palms, particularly *Eremospatha macrocarpa*. This forest merges with the *Guibourtia-Uapaca* forest, since on rising land the forest floor is periodically exposed. At the edge of the inundation zone, still on ground with a water table close to the surface, *Guibourtia* forest merges with evergreen rain forest.

Wetland Fauna: Some vagrant species of fish enter the lake from the Zaire River during high floods but do not develop populations in the lake. Altogether 111 resident species have been identified in the lake, together with about a dozen vagrants. Open waters support populations of small, plankton feeding, shoaling fish, belonging to the genera *Barbus*, *Clupeopetersius* and *Microthrissa*, together with their predators, such as *Hydrocynus vittatus*, *Mormyrops deliciosus* and *Odaxothrissa losera*. There are numerous mudsucking, detritivores or insectivores, which fall prey to other carnivorous species of *Chrysichthys*, *Malapterus*, *Monnyrops* and *Polypterus*. The plant communities of the quiet coves, with their abundant invertebrate faunas, attract many species feeding on vegetation, insects, freshwater crabs and detritus. Another spectrum of predatory fish occurs

here. An unusual group of predators, well represented in the lake, are those feeding almost exclusively on fins torn off other fish. These include species of *Belonophago*, *Eugnathichthys* and *Phago*. Endemism is low, and only *Clarias congicus*, *Clupeopetersius schoutedeni*, *Congolensis tumbanus*, *Eutropius tumbanus*, *Lamprolagus congolensis* and *Tylochromis lateralis microdon* have distributions restricted to the lake and its immediate environs.

Amphibians and their tadpole stages are abundant in the aquatic prairies near the banks. *Crocodylus cataphractus* is common, and *C. niloticus* is present though far less common. A tortoise, *Amyda* sp., varanid lizards, and some terrapins also occur here, together with numerous snakes, including *Boulengerina annulata*, *Python sebae* and various tree snakes. Most snakes associated with the lake are piscivorous. The birds and mammals are similar to those described in the previous section, 4a.

Human Impact & Utilisation: The human population is comparatively high on the eastern side of the lake, above average for the Zaire Depression, and reaches a density of 15 persons/km². Here the principal town, Bikoro, has over 1000 inhabitants. By contrast the west bank is very sparsely populated, with a density of less than 3 persons/km². The lake is fished commercially and the annual catch varied between 2000-3500 tonnes between 1964-1983 and most of the local people are engaged in, or associated with, the fishing industry, but there is some local agriculture. The principal species fished belong to the genera *Chrysichthys*, *Citharinus*, *Clarias*, *Eutropius*, *Mormyrops* and *Xenomystus*. There is a cargo and passenger boat service between Bikoro and Mbandaka which takes 21 days for the return trip, and carries on average 400 - 1200 tonnes of cargo upstream, returning with 1300-1800 tonnes.

Conservation Status: No part of the lake is protected, but it is proposed that the bays and channels of Bituka, Lobambo and Nganga on the sparsely populated southern and western shores should become an integral nature reserve. It is thought that the creation of such a reserve would not interfere with profitable fishing on the lake.

(c) Lake Mai Ndombe

Country: Zaire

Coordinates: 1°32'-2°43'S/18°03'-18°36'E

Area: c. 230 000 ha (open water area)

Altitude: c. 310 m asl

Nearest Towns: Bolobo (225 km W); Kinshasa (375 km SE)

General: The lake is entirely surrounded by equatorial forest and measures

135 km in length, with a mean width of 17 km. It is oriented N-S and reaches a maximum width of 55 km in the north, but tapers to a point where it discharges into the Fimi River in the south. The lake occupies an alluvial depression. It forms the lowest point of a shallow swampy basin and around most of its perimeter its banks shelve gently into the water and are densely forested. The water is shallow with a mean depth of perhaps 3 m. On the east and southwest the beds are of Pleistocene, or even Pliocene age, dating from the time when the entire depression was flooded, but in the northwest the beds are very recent.

Climate: The lake enjoys about 2100 hours of sunshine a year, with monthly receipts ranging from 140-185 hours, with maxima in May-June and a minimum in November. The mean annual incident radiation receipt is 127 Kcal/cm² and evaporation from the lake has been estimated as 1356 mm/yr. Relative humidity varies between 80-90% throughout the year, but with the lowest values, c. 80% being recorded at the southern extremity in August. The mean annual temperatures are close to 25.3°C all over the lake, with a mean figure of 25.9°C in March, and mean monthly maxima and minima of 30.9 and 22.4°C respectively, while the corresponding figures for November are 24.7, 29.4 and 21.1°C. Wind speeds are similar to those reported for Lake Tumba, but violent gusts are uncommon. Mean annual rainfall increases from 1700 mm in the south to 1900 mm in the north. Maximum falls of up to 225 mm occur in October, and minimum falls in July range from 10-50 mm. There is a short but distinct dry season, lasting 50 days in the north but nearly 80 days in the south over the June-August period.

Hydrology & Water Quality: Lake Mai Ndombe has 14 major affluents draining some 6 768 000 ha of very wet swampy land, the most important of which are the Lokoro and Lotoi which enter the northeastern arm of the lake and the Olongo Lule which enters the northwestern arm. The lake spills over into the Lukenie River, draining another huge area to the east, which is thereafter known as the Fimi River. This eventually discharges into the Kasai River. The black humic waters of Lake Mai Ndombe do not immediately mix with the clear waters of the Lukenie, so that after the confluence, the Fimi River has a ribbon of black water along the north bank and a ribbon of clear water along the south bank. Following the confluence with the Kasai, the brown Fimi waters also remain separate from the reddish Kasai waters for a long distance. Low water in the lake is reached in September and high water is from January-April, and there is an annual fluctuation of about 2 m in water level. The variation of mean water level also fluctuates by about 2 m from year to year. The rise of water levels during October-November is due in part to water entering from the Lukenie, with water flooding across country from this river 50 km upstream of the point where it picks up the effluent from Lake Mai Ndombe. It has been estimated that the water content of

the lake varies from 4-10 billion m³ over the course of a year.

The temperature is quite high, but there are no reliable figures. However, judging from the incident radiation regime and its shallowness, and drawing parallels with Lake Tumba, it is probably in the range of 28-30°C. The waters are dark and transparency is low, c. 80 cm. The pH range is 4.0-4.5. The water column is oxygenated throughout, but never saturated, and the level of mineralisation is very low.

Wetland Flora: Most of the lake is still completely enclosed by virgin equatorial forest, except in the immediate vicinity of a few small villages and in the far south where, between the banks of the Lukenie and Fimi Rivers and the southern tip of the lake, much seasonal swamp forest has been cleared for agriculture. Virtually all the surrounding forest is subject to periodic inundation, but permanent swamp forest is concentrated in the north, along the courses of the rivers entering there. The most extensive area is from the NE arm of the lake southeastwards along the Lokoro River, where the main block extends for 153 km upstream and in places spreads for over 40 km on either side of the river. Patches of permanent swamp forest also occur farther upstream on the Lokoro and its tributaries, the Lole and Lula Rivers, and this is the case on all the affluent streams. *Raphia* swamps occur around the shores in the wettest sites, made impenetrable by the presence of spiny climbing palms, principally *Eremospatha* spp. These grade into *Oubanguia africana* and *Guibourtia denteusei* forests in less permanently inundated places, and these in turn to terrestrial evergreen rain forest on unflooded land. There have been no proper botanical surveys of Lake Mai Ndombe.

Wetland Fauna: There have been no zoological surveys of Lake Mai Ndombe, and what is known stems from travellers reports. Among invertebrates, the medusa of *Limnocoeloides congoensis* has been found there, and freshwater crabs, *Potamonautes* spp., are plentiful. As far as the fish fauna is concerned, some inventories were made at the beginning of this century. By 1918 some 40 species were known from the lake including *Alestes binzaculatus*, *Gnathonemus leopoldianus*, *Marcusenius nigropinnis* and *Notopterus afer*. *Alestopetersius leopoldianus*, *A. nigropterus* and *Nannothrissa stewartii* are endemic. The lake contains terrapins, *Pelosios* spp., and three crocodiles, *Crocodylus cataphractus*, *C. niloticus* and *Osteolaemus tetraspis* (de Bondt, 1969); also *Boulengerina annulata* together with several semi-aquatic snakes.

The avifauna appears to be rich, and most of the Central African aquatic birds are found there, although there are no official lists. A comparatively rare species is the small kingfisher, *Corythornis leucogaster leopoldi*. Mammals associated with the lake are similar to those found along rivers in

the central depression dealt with earlier in section 4a.

Human Impact & Utilisation: Population density around the lake is low, about 4 persons/km², but falling to 2 persons/km² in the south. The two centres of population are Kutu at the confluence with the Lukenie River in the extreme south and Inongo on the east bank. There is some small scale agriculture and oil palm, *Elaeis guineensis*, is grown locally around the lake, also on a small scale. In the SW, between the lake and the banks of the Lukenie and Fimi Rivers, rice is cultivated, and there have been extensive clearances for this, the rice being grown in what were formerly seasonal swamp forest areas. Some millions of hectares of forest have succumbed in an area extending 15-20 km from the lake and river banks. Fishing on the lake produces an annual catch of about 1000 tonnes, but the maximum sustainable yield has been estimated as 10 000 tonnes in 1983. There are boat services between the lake and Kinshasa, carrying up to 5000 tonnes of merchandise/yr in both directions.

Conservation Status: Unprotected.

5. Wetlands of the Eastern Highlands

Co-ordinates of Region: 4°41'N-8°27'S/28°00'-30°32'E

Area of Region: c. 267 345 km²

Altitudinal Range: 650-4507 m asl

General: The region under consideration lies between longitude 28°E and the mountainous watershed along the eastern border which separates the Central Zaire Basin from the basins of the Rift Valley Lakes. In altitude it rises from about 650 m asl in the west to over 3000 m asl at several points in the Mitumba Mountains. Along the eastern border there are 6 principal massifs, all with great plateau-like tops 1500-2000 m asl, all also surmounted by higher peaks. It is the elevated plateaux at the feet of the mountains that are important for their wetlands. These plateaux, from north to south, cover more than 937 500 ha above the western shore of Lake Albert, more than 900 000 ha above the western shore of Lake Edward, more than 600 000 ha above Lake Kivu, and in three blocks, more than 2 750 000 ha along the western shores of Lake Tanganyika. Streams from the summits meander over the plateau, with innumerable swamps along their courses, in valleys which are little incised, but then plunge down the steep and deeply dissected western slopes, with waterfalls and rapids, before their beds again flatten below the 1000 m contour, en route to the Zaire River. Drainage to the east is by short torrential streams, descending by serried steps to the floor of the Western Rift Valley.

Climate: Climate throughout the region varies greatly with altitude. In

general there is a tight correlation between altitude and the temperature of the coldest month. Below 1000 m this is in the vicinity of 23°C, but 19°C at 1500 m, and below 15°C at 2000 m asl. There is little seasonal variation in mean monthly temperature near the equator, but it becomes apparent over the Marunga Massif at the southern end of Lake Tanganyika. The permanent snow line is close to 4500 m asl, and although this height is attained at Mt. Karisimbi (4507 m) and Mt. Stanley (5110 m), a snowfield exists only around the latter. Mean annual rainfall exceeds 2200 mm between 1000 -1300 m on the western slopes of the plateaux in the equatorial zone, and exceeds 2800 mm on some of the higher slopes. However, it appears to be less great in an intermediate zone between 1500 -1800 m asl. Here it seldom exceeds 2000 mm/yr. Precipitation decreases progressively in moving north or south away from the equator, reaching maxima close to 1500 mm/yr on the Marunga Massif in the far south.

Wetland Flora: There are two principal phytogeographic regions, one SoudanoZambeian, and the other Guinean. The former occurs above 1300 m on the plateaux, on the eastern slopes, and on parts of the western slopes. The lower western slopes are the province of dense wet rainforest or semi-deciduous forest of Guinean affinity.

Vast swamps occur on the summit plateaux in the headwater regions of the myriad streams, and there are wet formations of lesser extent on some of the eastern and western slopes. On the plateaux human activities have influenced the marshy vegetation, locally ending to make it very uniform, as discussed in the appropriate subsection. For this reason a small number of discrete associations can be recognised. *Cyperus papyrus* dominates large deeply inundated areas around lakes and ponds, e.g. around the 4 Mokoto Lakes NW of Lake Kivu, and in the Kabare (2°28'S/28°47'E) district. Small deeply inundated permanent swamps along streams are generally covered by *Typha domingensis*, or by this species together with *Cyperus latifolius*. *Miscanthidium violaceum* dominates huge areas of swamp on flat wet surfaces away from the main watercourses, though small streams may traverse them, when they are generally fringed by *Typha*. *Miscanthidium* forms tall coarse tufts, 4-5 m high, with a lower storey of *Scleria* spp., and with *Nymphaea ntilibraedii* on water or mud between tufts. *Phragmites mauritianus* seems to be almost completely confined to the eastern slopes where it fringes deeply furrowed watercourses on the steep slopes, and spreads out into the small deltas which streams build into the lakes. However, *Cyperus latifolius* is the most widespread plateau species. It covers great areas, in almost pure stands, reaching 1.5 m in height, but around the edges other heliophilic species become abundant and chief among these are *Alchemilla*

mildbraedii, *Polygonum strigosum* and *Thelypteris squalnigera*. This association tends to be colonised by woody species, producing a canopy around 3 m high, and the most common species involved are *Hypericum lanceolatum*, *Maytenus acuminatus* and *Myrica kandiana*.

At lower altitudes periodically flooded forests along rivers are similar to those of the central depression. *Uapaca guineensis* often forms pure stands, but possibly these are secondary in nature. Nevertheless, this species is dominant in much of the higher riverside forest, especially away from the equator. In the far north and south it is joined by *Ficus mucosa*, *Irvingia smithii*, *Klainedoxa* sp., *Mitragyna stipulosa* and *Syzygium* cf. *cordatum* in gallery forest, sometimes also by *Chlorophora excelsa* and, in the north, by *Khaya senegalensis*. Below 1000 m, galleries of *Gilbertiodendron dewevrei* and *Staudtia stipitata* occur along watercourses, but with *Mitragyna stipulosa* forest in any semi-permanently swampy areas. *Gilbertiodendron* forest interdigitates with another type of ombrophilous evergreen forest, comprising almost monospecific stands of *Michelsonia microphylla* in the equatorial region. This forest occurs under the very wet climate along the lower western slopes of the massifs between altitudes of 650-1200 m, on soils that are always wet, if not swampy.

In some of the savanna regions, in places of great seasonal pluviosity, where the soil is poorly drained, *Kotschyia africana* and *Setaria sphacelata* often form a mosaic vegetation.

Wetland Fauna: At the lower elevations the gallery forest, swamp forest and riverine forest faunas include *Cephalophus nigrifrons*, *C. sylvicultor*, *Cercocebus albigena* (N only), *Cercopithecus aethiops*, *C. albogularis* (N only), *C. ascanius*, *C. mills stuhlmanni* (N only), *C. mills kandti* (Kivu region), *Colobus badius*, *C. guereza* (N only), *Felis aurata*, *Genetta tigrina*, *Herpestes ichneumon*, *H. sanguineus*, *Kobus ellipsiprymnus*, *K. kob*, *Leptailurus serval*, *Neotragus betesi* (NE only), *Osbornictis piscivora*, *Panthera pardus*, *Phacochoerus aethiopicus*, *Potamochoerus porcus*, and *Syncerus caffer*. *Hylchoerus meinertzhageni* occurs in montane forests, and *Phacochoerus* is more common towards the east. A cline is evident from west to east, along which elephant populations increase in size from the small forest elephant, *Loxodonta africana cyclotis*, to the bush elephant, *Loxodonta africana africana*. The usual small semi-aquatic mammals, *Aonyx capensis*, *Atilax paludinosus*, *Dasymys* sp., *Lutra nzaculicollis*, *Pellomys* sp. and *Potamogale velox* extend upward into the higher forests, and most occur in the plateau herb swamps. Here, at least in the south, *Thryonomys swinderianus* is also present. *Aonyx capensis* has been recorded above

3000 m, while *Atilax* and *Lutra* have been observed 2000 m asl. *Aonyx congica* is uncommon above 650 m.

Human Impact & Utilisation: Large areas of this region are very sparsely populated, but close to small centres of population the herbaceous wetland vegetation is heavily exploited for thatch and fibre for basketry and fish traps, and it is cut regularly over large areas, limiting the dominant vegetation to those species which survive this treatment. The rivers are fished throughout the region, illegally in the national parks, where there is also some poaching of elephant and antelope.

Conservation Status: There are 3 national parks in this region. The Garamba National Park is situated on the border with Sudan in the far north, and here poaching has been intense in recent years. For example, elephant numbers in the park fell from 22 000 in 1976 to 8000 in 1983, and recurrent civil unrest in neighbouring countries does not improve the situation. In this park, in a predominantly savanna area, gallery forest and papyrus swamps are protected. To the south, in the Maiko National Park, strips of swampy riverine forest are protected, and in the Kahuzi-Biega National Park all the wetland types of the plateaux and mountainsides are protected.

6. Lake Tanganyika & the Ruzizi Plain

(a) Lake Tanganyika

Country: Zaire

Coordinates: 3°21'-8°51 'S/29°04 '-31°12 'E

Area: 3 290 000 ha (c. 1 502 200 ha in Zaire)

Altitude: 773 m asl

Nearest Towns: Kabalo (255 km W); Lubumbashi (500 km SW)

General: Lake Tanganyika is 659 km long with a maximum width of 85 km at the parallel 5°55'S. It is slightly brackish and the second deepest lake in the world (1470 m). It lies in the western arm of the Great Rift Valley and down most of its western side the escarpment plunges straight into the water, and in the south basin it continues underwater to the maximum depth of 1470 m, which is reached just 4 km offshore. Only at the northern and southern ends is the underwater slope moderate, and even in these places the 100 m contour is reached inside 10 km. The adjacent mountain ranges exceed 3000 m asl at the northern end of the lake, which is fed by several large rivers, and countless small streams which enter all round its periphery, in Zambia, Tanzania, Burundi and Zaire. The Ruzizi River, draining Lake Kivu, descends the Panzi Falls before entering Lake

Tanganyika so that the two lakes are faunally isolated. The Ruzizi has formed a substantial delta at the north end of Lake Tanganyika. The other principal affluent is the Malagarasi River, which drains much swampy land to the south of Lake Victoria. The lake drains from the middle western section via the Lukuga River to the Lualaba, but water levels fluctuate over long time periods, much as they do in Lake Malawi to the south, and these are discussed by Camus (1965). The flora, fauna, hydrology, water chemistry and geological history of the lake proper are dealt with in detail in section 2.9.4b, Lake Tanganyika. However, brief account of the fish fauna, and the lake and delta floras are given here. The flora and fauna of the Fizi Plain, at the head of the large bay near Fizi (4°18'S/28°56'E), is quite similar to that of the Ruzizi Plain described in the next section.

Wetland Flora: *Ceratophyllum demersum* is abundant in the vicinities of affluent river mouths, while in the deltas of several rivers *Azolla pinnata* may form immense floating mats, green or red-brown in colour, and there are great submerged beds of *Myriophyllum spicatum*, *Najas marina*, *N. pectinata*, *Ottelia ulvifolia*, *Potamogeton pectinatus* and *P. schweinfurthii*. *Potamogeton* spp. are the predominant macrophytes around much of the shoreline, with occasional rafts of *Nymphaea caerulea* and *N. capensis* in shallow sheltered bays. *Cyperus papyrus*, *Phragmites mauritianus* and *Typha domingensis* dominate the delta swamps, with *Vossia cuspidata* as principal low growing associate.

Wetland Fauna: The lake contains a large fish fauna, comprising some 193 species from 13 families, an analysis of which suggests that the lake is ancient and has been isolated for a long time. Although 98% of the cichlids and 57% of the non-cichlid species are endemic, similar proportions to those found in the faunas of Lakes Malawi and Victoria, it is the degree of speciation here, which distinguishes Lake Tanganyika from the others. It contains no less than 8 endemic genera, and some endemic species reveal distinct subspecific forms between the north and south ends of the lake. Comparatively recently Zaire Basin species have invaded the lake, presumably by way of the Lukuga River, the most recent effluent. These include *Distichodus fasciatus*, *Hydrocynus goliath* and *Labeo lineatus*. Other interesting species include *Protopterus aethiopicus*, *Polypterus congicus* and *P. ornatipinnis*, also Zaire Basin species which live in lagoons and deltas around the lake, especially the Malagarasi Delta. These are ancient fish and their presence has probably been continuous from the time when the Malagarasi flowed directly into the Zaire Basin, before the faulting which led to the development of the Rift Valley and its lakes. There are two fully aquatic piscivorous snakes in the lake. *Boulengerina annulata* lies up in the rocks during the day and fishes nocturnally, while *Glypholycus bicolor* hunts pelagic fish, chiefly shoals of *Stolothrissa*

tanganicae.

Human Impact & Utilisation: The lake is fished intensively from several ports including Uvira, Kalemie (Albertville) and Moba (Baudouinville) in Zaire.

Conservation Status: Unprotected.

(b) The Ruzizi Plain

Country: Zaire

Coordinates: 2°32'-3°21'S/28°56'-29°35'E

Area: 184 000 ha (total lower plain)

Altitude: 773-810 m asl

Nearest Towns: Bukavu (47 km N); Kongolo (350 km SW)

General: The Ruzizi Plain occupies the floor of the Western Rift Valley at the northern end of Lake Tanganyika, and has been transgressed by lake water in the past. The lower plain slopes very gently southwards to the lake, and the Ruzizi River meanders across the centre of the plain, roughly from north to south, forming the national border with Burundi. On either side of the plain the land rises steeply into the mountains. Precipitation over the lower plain is 800-900 mm/yr, while on the slopes of the valley it is 1200-1300 mm/yr. April is the wettest month with mean falls of 140-160 mm in the plain and 180-200 mm in the hills, depending upon site. The dry season usually begins in the second half of May and persists until the end of September, but is longer in the south than the north. Winds are generally light in the morning, increasing to peak velocities at midday, when they may attain 20 km/hr in the wet season and 28 km/hr in the dry season. Mean monthly temperatures range from 22.5-25°C, while mean monthly maxima and minima are 30.5-32.5°C and 14.5-17°C respectively. There are extensive wetlands on the plain, chiefly associated with the Ruzizi River and its tributaries.

Wetland Flora: *Phragmites mauritianus* swamps accompany the Ruzizi River, in a belt up to 3 km wide along the lower half of its 135 km course between Lake Kivu and Lake Tanganyika and into its delta, but along its tributaries these swamps are reduced to much narrower strips, e.g. on the Sange and Kiliba Rivers. The swamps are broader in the south than the north, and it is estimated that the area of reedbeds may exceed 20 000 ha. Where inundation is permanent the reeds reach 4 m in height, but where it is seasonal they are little more than 2 m high. The most important associate species are *Ipomoea fragrans*, *Panicum meyerianunz*, *Paspalidium geminatum* and *Polygonum pulchrum*, the last three species being especially well represented where the surface waters are ever only superficial.

On the sides of lakes, on meander bends and around small islands in the river,

one finds sandy beaches, subject to periodic inundation, but with groundwater always near the surface. These places are covered by a *Cyperus laevigatus-Pluchea bequaertii* association. There is generally a distinct upper stratum, reaching 1.5-2 m, comprising suffrutescent species, dominated by *Pluchea bequaertii*, with *P. dioscoridis* and *P. ovalis*, and a ground cover of *Cyperus laevigatus* and *Fimbristylis ferruginea* reaching 30-125 cm.

The country adjacent to the floodplain is *Themeda-Bulbine* grassland, but throughout this there are small ponds which provide waterholes for domestic cattle. They are flooded to depths of over 1 m in the rainy season but are transformed into quagmires during the dry season, and support a flora of *Oryza barthii*, with *Asteracantha longifolia* and *Burnatia enneandra* on the fringes, and sometimes central patches of *Nymphaea lotus* and *Utricularia thonningii*. From place to place the *Themeda-Bulbine* association is interrupted, in periodically inundated depressions on the lowest terraces, by swards of *Sporobolus spicatus* which are heavily grazed by local cattle in the dry season. This is the most halophilic association on the valley floor, under which the soil water contains salts to a total concentration of 8‰. Elsewhere, in large shallow depressions in the *Themeda-Bulbine* savanna, where the gradient is virtually nil, water collects semi-permanently. The ground surface is always muddy, particularly where trampled by cattle, but surface water is seldom more than a few centimetres deep. These areas support a cover of *Panicum ruziziense*, with some *Ammania senegalensis*, *Cyperus platycaulis*, *Desmodium hirtum*, *Ilysanthes parviflora*, *Lindernia boutiqueana* and *Ophioglossum costatum*.

Another very local hydromorphic association in this large wide valley is that of *Setaria holstii* and *Botriochloa insculpta*. This occupies depressions along the valley floor that were once the beds of lakes. They have clay floors and are inundated for most of the wet season, but dry completely during the dry season, when the clay hardens and cracks.

Other species found here include *Digitaria scaettae*, *Glycine borianii* and *Paraknoxia ruziziensis*, together with vagrants from the surrounding savanna.

Where the rivers traverse the metamorphic terrain at the feet of the mountains they flow in very steep sided valleys, and throughout these regions the narrow banks carry gallery forest dominated by *Baphia descampsii* 10-12 m high, with *Craibia grandiflora*, *Cissus araliodes* and *Sterculia tragacantha* as typical associates.

Wetland Fauna: Some reptiles are present, including various swamp

snakes, *Dromophis lineatus*, *Limnophis bicolor* and *Philothamnus irregularis*, together with varanid lizards and occasional crocodiles. Among the notable birds of the flood plain and permanent herb swamps, *Actitis hypoleucos*, *Acrocephalus schoenobaenus*, *A. scirpaceus*, *Calidris ferruginea*, *C. minuta*, *Chlidonias leucoptera*, *Cuculus canorus*, *Delicon urbica*, *Falco subbuteo*, *Glareola nordmanni*, *Hippolais pallida*, *Hirundo rustica*, *Motacilla flava*, *M. feldegg*, *Pandion haliaetus*, *Phylloscopus trochilus*, *Porzana porzana*, *Riparia riparia*, *Tringa glareola* and *T. nebularia* may be cited. Mammalian wildlife has been largely displaced by domestic cattle, and in numbers, the wetlands now support only small mammals, otters, mongooses and water rats.

Human Impact & Utilisation: Both the Ruzizi Valley and the Fizi Plain are intensively cultivated, and the wet areas are frequented by domestic cattle in the dry season when large areas of wetland are burned.

Conservation Status: Unprotected.

7. Lake Kivu

Country: Zaire

Coordinates: 1°35'-2°31'S/28°49'-29°20'E

Area: c. 260 000 ha (excluding islands; c. 165 000 ha in Zaire) **Altitude:** 1460 m asl

Nearest Towns: Bukavu (at S end); Kongolo (460 km SW)

General: Lake Kivu lies in the western trough of the Great Rift Valley, enclosed on three sides by land which rises steeply from the lake to over 2000 m, and to 4507 m just to the north. The lake is 100 km long, and has a maximum width of 50 km almost exactly along the parallel 2°S. There are several islands in the lake, most small, and most in Rwanda, but Idjwi Island, 40 km long and with an area of 30 000 ha, is in Zaire.

Hydrology & Water Quality: The lake receives run-off from the surrounding mountains, and it is believed that warm water is injected into the lake from submerged hot springs. Further, effluents from the small group of Mokoto Lakes, to the northwest, disappear into the volcanic ash, but are believed to reach Lake Kivu. Rainfall in the catchments exceeds 2400 mm and is not markedly seasonal. The lake is deep, c. 480 m, meromictic, and the most firmly stratified lake in Africa. Water density increases towards the bottom, but not as a steady gradient; there are a series of discrete layers. The surface water has a salinity of 1‰, and the top 70 metres are mixed, but it seems that below this the hypolimnion is completely stagnant, highly saline, and very rich in nitrogen and phosphorus. The pH of the surface waters is about 9.1. It appears that

natural phenomena, other than earth movements and the pouring of hot lava into the lake, do not cause upwellings of the bottom water, which is highly nutritive but contains much dissolved sulphide and methane. The temperature at the surface is close to 25°C, decreasing with depth to about 22°C at 70 m, but then increasing again to 25°C at 375 m depth. The 70 m contour is very close to the shore, and since only the upper 70 m of the water column is oxygenated, it has been estimated that only 12% of the lake floor receives any oxygen. This is the most saline lake in the Western Rift Valley.

Wetland Flora: There is little information regarding the phytoplankton, but it is neither diverse nor abundant. The macrophyte flora, which extends down to a depth of 8 m, is extremely poor, and there is only a narrow fringe of lake bottom above this depth. The deep lake floor is covered by an organic ooze, but towards the shores the bottom is quite sandy, with an encrusting calcareous scale. Here *Cladophora* sp. is the dominant plant. Higher up there are beds of *Ceratophyllum demersum*, *Najas marina* and *Potamogeton pectinatus*, the latter species being most abundant. Around the shallowest margins there are beds of *Phragmites mauritianus* and species of *Cyperus* and *Scirpus*.

Wetland Fauna: The fish fauna is poor, comprising just 16 species. Of these, 3 also occur in Lake Tanganyika, namely *Barbus serrifer*, *Barillus moori* and *Clarias mossambicus*. The first and last have wide distributions, but *Barillus moori* is found only in these two lakes. There are 6 species of *Haplochromis*, all endemic, and a distinct subspecies of *Oreochromis niloticus* ssp. *regani*, which suggests that speciation has occurred in the lake over the last 20 000 years. There is no large predatory species in the lake. Birds and otters are the principal piscivores, and the lake supports many birds of passage.

Human Impact & Utilisation: *Limnothrissa miodon* was introduced some years ago, and a small sardine fishery has developed, but prior to this there was no commercial fishery of significance.

Conservation Status: Unprotected. The high mountain catchments to the north however, are protected in the Virunga National Park.

8. Lake Edward

Country: Zaire

Coordinates: 0°05'- 0°56'S/29° 16'-29°56'E

Area: c. 234 200 ha (170 450 ha in Zaire)

Altitude: 912 m asl

Nearest Towns: Lubero (28 km W); Bukavu (225 km SSW)

General: Lake Edward is 76 km long with a maximum width of 39 km. It is connected to Lake George, effectively a bay of Lake Edward, by the Kazinga Channel, 40 km long and less than 1 km wide. Lake Edward reaches a maximum depth of 112 m, just 5 km from the western shore, above which the land rises precipitously to a high plateau over 2000 m asl carrying mountain peaks over 3000 m. By contrast the lake floor slopes up gradually to the Uganda shore.

Hydrology & Water Quality: Lake Edward has numerous affluent streams, the most important being the Nyamugasani River from the Ruwenzori Mountains and the Ishasha, Rutshuru and Rwindi Rivers from the Virunga Volcanoes and the Rwanda Highlands. Further inflow comes from Lake George, which also drains the Ruwenzori Range and to the east shares a watershed with Lake Victoria. However, flow through the Kazinga Channel is very sluggish, along a remarkably gentle gradient of 1:80 000 over the first 24 km. The junction of the waters between Lakes Edward and George, indicated by a change in colour, but also in chemistry, can usually be seen in the Kazinga Channel. The position of this boundary oscillates up and down the channel over a distance of about 3 km seasonally. Lake George is fresh, and its water chemistry is known to have remained fairly constant over the last 40 years, suggesting that the residence time of water in the lake is short, and that evaporation does not lead to the concentration of solutes. However, no subterranean outlets are known, yet the flow into Lake Edward appears minimal. Precipitation over Lake Edward is only 500-650 mm/yr, the lowest in Zaire, but is much higher in the adjacent mountains, e.g. approaching 3000 mm/yr on the western slopes of the Ruwenzori Massif, the highest in Zaire. Lake Edward discharges into the Semliki River, and thence to Lake Albert and the Nile. Water spills over a rock shelf at the northern extremity of the lake, which functions as a natural weir. Water leaving the lake has a temperature of 25-26°C and a pH close to 9.1. The lake is more saline than Lake Albert and less saline than Lake Kivu.

Wetland Flora: *Potamogeton pectinatus* is the dominant submerged macrophyte, in association with *Najas marina* and *Vallisneria aethiopica*. Some *Potamogeton schweinfurthii* and *Najas pectinata* occur along the eastern shores. *Vallisneria* and *Najas* are best developed in the vicinity of river mouths where waters are better aerated. *Cyperus papyrus* and *Phragmites mauritianus* form swamps at the mouths of effluent streams, which are especially well developed along the southern shore. Riverine swamps extend back from the lake up all three principal rivers entering the southern end of the lake for distances of several kilometres.

Wetland Fauna: The present fish fauna comprises about 23 cichlids and 30 non-cichlid species. However, the fauna is impoverished, with certain widespread families being entirely absent, e.g. Centropomidae, Characidae, Malapturidae, Mastacembalidae, Mochokidae and Schilbeidae. Further, *Citharinus*, *Distichodus*, *Hydrocynus*, *Polypterus* and *Lates*, which are found in Lake Albert and the Nile, are also absent, although both *Hydrocynus* and *Lates* are known to have been present in the middle Pleistocene. From palaeontological studies a picture emerges of Lake Edward being in a phase of recolonisation, its fauna having been partially eliminated at least twice during the late Pleistocene. Although the lake once contained crocodiles, as well as the Nile fish cited, they are also now absent. The rapids prevented their re-introduction from the lower Semliki where they persisted until the middle of this century before they were finally eliminated by hunters. However, it appears that fish have entered from the east, where there is now a watershed with Lake Victoria, and have begun speciating. In the cichlid fauna there are several species with close relatives in Lake Victoria, e.g. *Haplochromis guiarti*, *H. ishmaeli* and *H. macrops* and two common species, *Astatoreochromis alluaudi* and *Haplochromis nubilis*. Two species present in the Nile have either re-entered or survived, *Bagrus docmac* and *Oreochromis niloticus*. *Oreochromis leucostictus* is confined to Lakes Edward and Albert, perhaps having originated in Lake Edward, and passed downstream. Considering the history of the lake the invertebrate fauna is surprisingly rich.

The avifauna of the lake and associated river valleys and swamps is very diverse and includes herons, ibises, egrets, bitterns, ducks, geese, darters, cormorants, skimmers, shoebills, openbills, ospreys, gulls, francolins, warblers and weavers. Large numbers of pelicans frequent the lower Rutshuru River. Species of interest include *Acrocephalus schoenobaenus*, *A. scirpaceus*, *Anas querquedula*, *Ardeola ralloides*, *Calidris ferruginea*, *C. minuta*, *Charadrius hiaticula*, *Chlidonias leucoptera*, *Gelochelidon nilotica*, *Hirundo rustica*, *Philornachus pugnax*, *Riparia riparia*, *Tringa glareola*, *T. nebularia* and *T. stagnatilis*.

Human Impact & Utilisation: Relatively little since the proclamation of the national park in 1969, but illegal fishing and poaching on the lower Rutshuru are chronic problems. Growing tourism could prove a threat, and the proposal to dam the Rutshuru River would almost certainly have a major, and adverse, impact upon the riverine wetland ecosystem.

Conservation Status: The entire Zairean section of the lake is protected in

the Virungas National Park, as is the lower course of the Rutshuru and several other tributary rivers.

9. The Semliki River Valley

Country: Zaire

Coordinates: 1°20'N- 0°11' S/29°30' -30°30' E

Area: c. 375 000 ha

Altitude: 619-912 m asl

Nearest Towns: Bunia (25 km N); Bukavu (300 km SSW)

General: The Semliki loses 293 m of altitude over its 150 km course from Lake Edward to Lake Albert. The upper course is swift, rocky and boulder strewn, 30-40 m wide, and enclosed by the dense Ituri Forest. Most of the descent is made over two rapids sections in this part of the river. In places the river is confined to a narrow channel, 10 m wide, between sheer rock walls. On emerging onto the savanna covered, lower Semliki Plain, the river flows slowly, eventually meandering to its delta in Lake Albert. A chain of oxbow lakes to the west of the present lower course, and deltaic deposits in Lake Albert, indicates that the river bed has been moving eastwards over the lower plain. Swamps occupy an area 15 km wide and 3.5 km deep along the southern shore of Lake Albert astride the delta of the Semliki, which projects a further 3 km into the lake. Upstream, seasonally inundated land extends back from these swamps in a belt 3-7 km wide for many kilometres, and a large area, centred upon the oxbows of the abandoned river course, is poorly drained and comprises hydromorphic soils. Farther back upstream, smaller swamps occur along the Semliki at numerous isolated sites, mostly where tributaries enter the mainstream.

Wetland Flora: *Cyperus papyrus* and *Phragmites mauritianus* dominate the riverine and delta swamps, reaching heights of 5 m. Much of the unflooded lower valley floor is covered by *Themeda* savanna, and in this, saline hydromorphic soils support vast swards of *Sporobolus spicatus*. Elsewhere, seasonally inundated soils are covered by species of *Hyparrhenia*, *Loudetia* and *Pennisetum*, with *Pennisetum purpureum* and *Imperata cylindrica* representing post-cultivation grasses. The former occurs on the wettest soils, the latter on drier fringes subject to fires. Gallery forests contain a spectrum of typical Zaire species, together with some of more East African affinity.

Wetland Fauna: The fish fauna is alluded to in sections 8 and 10. Among the reptiles, crocodiles are believed to have become extinct in the region as a consequence of intensive hunting, but varanid lizards are common, as are snakes. These include *Dromphis lineatus*, *Limnophis bicolor*, *Naja*

sp., *Natriciteres olivacea*, *Philothamnus irregularis* and *Psammophis olivacea* in the swamps, and various arborescent species, including *Dasypeltis scabra*, *Dispholidus typus*, *Dendroaspis angusticeps* and *Thelotornis kirtlandii*.

Birds are prolific and diverse, the spectrum changing abruptly at the transition from tropical closed forest to savanna, and finally to marshland at the delta. The range of piscivores from the latter sites includes pelicans, herons, ibises, egrets, gulls, fishing eagles, ospreys, skimmers, darters, cormorants and kingfishers, while the rare yellow papyrus warbler, *Chloropeta gracilirostris*, has been recorded from the lower Semliki, together with ducks, geese, moorhens, weavers and a variety of other warblers. Species of interest include *Buteo buteo*, *Chlidonias leucoptera*, *Ciconia ciconia*, *Crex crex*, *Cuculus canorus*, *Falco subbuteo*, *Gallinago media*, *Gelochelidon nilotica*, *Lanius collurio*, *L. minor*, *Lymnocyptes mininius*, *Merops apiaster*, *Pernis aprivorus*, *Phylloscopus trochilus*, *Porzana porzana*, *P. pusilla*, *Riparia riparia*, *Tringa glareola* and *Tochropus*.

Mammalian populations along the Semliki River are large and species found in these areas include *Aonyx capensis*, *Atilax paludinosus*, *Cephalophus* sp., *Damaliscus lunatus*, *Dasymys* sp., *Herpestes ichneumon*, *Hippopotamus amphibius*, *Kobus ellipsiprymnus*, *K kob*, *Loxodonta africana*, *Lutra maculicollis*, *Osbornictis piscivora*, *Phacochoerus aethiopicus* and *Syncerus caffer*.

Human Impact & Utilisation: Of recent years this has been slight, but poaching of elephants continues, and fishing and tourism are potential threats. The proposal to dam the Semliki River will, if implemented, have a major adverse impact upon the riverine ecosystems, possibly compounding damage done by impounding the Rutshuru above Lake Edward.

Conservation Status: A great deal of the Zairean part of the Semliki Valley, including the entire upper forested section, is protected in the Virungas National Park. This was established in 1925 as Albert National Park, and became the Virungas National Park in 1969. It was designated a World Heritage Site in 1979. The park is contiguous with national parks and wildlife sanctuaries in Uganda and Rwanda.

10. Lake Albert

Country: Zaire

Coordinates: 1°01'-2°07'N/30°23'-31°26'E

Area: 565 915 ha (247 345 ha in Zaire)

Altitude: 619 m asl

Nearest Towns: Kisangani (575 km WSW); Bukavu (450 km SSW)

General: Lake Albert lies between two parallel escarpments in the Western Rift Valley, at an altitude of 619 m, with an extreme length of 180 km and a maximum width of 43 km. Just under 44% of its surface is in Zaire. Its deepest point, 56 m, lies 7 km off the western shore, from where the land rises steeply to a high plateau more than 2000 m asl. The lake floor slopes gently upwards towards the east, but the eastern escarpment rises abruptly just a few km from the east bank in Uganda. The lake is subject to violent windstorms which cause the upwelling of bottom waters, but even without these happenings, the lake is generally well mixed. During calm periods, which frequently occur between November and February, a degree of stratification develops and dissolved oxygen levels fall, but not deleteriously for the fauna.

Hydrology & Water Quality: The principal affluent streams are the Semliki, which enters at the southern end, and the Victoria Nile, which enters very close to the northern end. Both rivers have built deltas into the lake. While the Nile carries more water than the Semliki, it has little influence on the ecology of the lake, other than to maintain water levels. The Nile water is fresh, with a salinity of 0.1700, while the main body of lake water, up to 10 km from the delta which the Victoria Nile has built into the lake, has a salinity of 6‰ and a pH close to 9.0. Lesser streams entering the lake from Zaire are, from south to north, the Kisege, Ndrigge, Muita, Nyamusiki, Kilowir and Mboge Rivers. However, all these, and other small rivers entering from the Ugandan side, are highly seasonal and of only secondary importance to the two major rivers. Some periodically inundated land occurs around the southern margin of the lake in the vicinity of the Semliki River Delta, and also along the eastern shore at some isolated spots, notably the Victoria Nile Delta. The results of detailed hydrobiological surveys were published by the Institut Royal des Sciences Naturelles de Belgique (Brussels) between 1957-1962. General information is provided by Bishop (1965; 1969) and Livingstone (1976).

Wetland Flora: *Potamogeton schweinfurthii* is the dominant submerged macrophyte over most of the lake, by contrast with Lakes Kivu and Edward where *P. pectinatus* is most common. However, this latter species is also present in Lake Albert. The principal associate species are *Najas marina* and *Vallisneria aethiopica*, and as in the other lakes, they are most abundant in the vicinities of river mouths, but this phenomenon is not so pronounced as it is in the two other lakes, possibly because Lake Albert is shallower and its waters are generally well oxygenated. In the river deltas, there are extensive stands of *Cyperus papyrus* and

Phragmites mauritianus, the flowering culms of which reach 4.5 m in height, with aquatic meadows of *Vossia cuspidata* on the lakeward side, and twining thickets of *Cyclosorus striatus* on the landward side. In ponds in the swamps, and in sheltered coves around the lake, there are floating-leaved and free-floating associations, notably a *Lemna paucicosta*-*Pistia stratiotes*-*Azolla nilotica* association, and a *Nymphaea calliandra* association. In the latter, *Najas marina*, *Nymphaea lotus* and *Vallisneria aethiopica* are usually to be found, together with free-floating plants of *Ceratophyllum dentersunt* and *Utricularia thoningii*. Species of *Nitzschia* and *Stephanotis* are the chief planktonic diatoms, undergoing periodic fluctuations in density. Blooms of the blue-green alga, *Anabaena* sp., occur locally from time to time, and lead to the mass mortality of fish, especially *Lates niloticus*.

Wetland Fauna: The fish fauna comprises 46 species, of which 22 are also found in the Nile. Some genera, e.g. *Bagrus*, *Heterobranchus* and *Lates*, have long histories in the lake, having been recognised from mid-Pleistocene sediments, while *Claroetes*, which was present in the Pleistocene, is no longer there. *Alestes baremose*, *Citharinus citharus*, *Lates niloticus* and *Oreochromis niloticus* form the basis of the present fishery. Two distinct populations of *Lates niloticus* are present, one which breeds in the lake, and another which migrates into rivers to spawn. In Lake Albert this species is an inshore form and is largely piscivorous, whereas another species, *Lates microphthalmus*, is pelagic and feeds mainly on *Caradina* (a freshwater prawn). Among the other piscivores both *Hydrocynus vittatus* and the smaller *H. forskalii* occur in the lake, but the latter, here, tends to be pelagic and also feeds very largely upon *Caradina*. Of 36 non-cichlid species, 3 are endemic, while of 10 cichlids, 4 are endemic. These are all species of *Haplochromis*. The cichlid fauna is poor compared with that of most other East African Lakes, including some other 'nilotic' lakes, such as Lake Edward. Accounts of the fish fauna are given by Worthington (1929) and Holden (1967; 1970). The invertebrate fauna is discussed by Green (1967a,b; 1971) and Verbeke (1957a,b).

Birds of interest found along the lakeshore are *Buteo buteo*, *Chlidonias leucoptera*, *Ciconia ciconia*, *Crex crex*, *Cuculus canorus*, *Gallinago media*, *Gelochelidon nilotica*, *Lanius collurio*, *L. minor*, *Lymnocyrtus minimus*, *Merops apiaster*, *Muscicapa striata*, *Pernis aprivorus*, *Phylloscopus trochilus*, *Porzana porzana*, *Riparia riparia*, *Tringa glareola* and *T. ochropus*.