CHAPTER 3 Description of Study Region

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CHAPTER 3

Description of Study Region

Farming near Aking-Osomba on the edge of the Oban Hills, near boundary of Cross River National Park, Nigeria.

PHYSICAL GEOGRAPHY

Our study region covers approximately 109,000 km^2. Its western boundary, at 5°16'E, is where the western major branch of the Niger—the Forcados River—reaches the Gulf of Guinea, and its eastern boundary lies where the Sanaga River leaves the moist lowland forest zone, at about 12°E. The most northerly extension of the moist lowland forest zone in this region is just south of the towns of Obudu and Ogoja in Nigeria, at about 6°40'N (White 1983), and the southern limit of the region is the southeastern corner of Bioko Island (Punta Santiago) at 3°12'N. Parts of the montane flora and fauna of the region extend at least as far north as 7°00'N in the northern extensions of the Cameroon Highlands along the Cameroon-Nigeria border.

Topography and drainage

Figure 1 displays relief in the project region. This map is taken from the GTOPO30 global digital elevation model (completed in late 1996 through a collaborative effort led by the USGS EROS Data Center). Like much of the information we located in widely-used databases, many details in the data used for this model were inaccurate for our study region. For example, these data do not portray the fact that much of the Obudu Plateau is above 1,500 m elevation; and they show the region around Port Harcourt in Nigeria, just east of the Niger Delta, rising to over 400 m, when in fact this area lies close to sea level. However, the GTOPO30 data were the best we could locate in readily-available digital form for entry into our GIS.

The western part of the study region, between the Niger and Cross Rivers in Nigeria, is generally low-lying (<600 m above sea level) with little relief other than the range of hills between Okigwi and Nsukka. The southwestern portion of this segment includes the Niger Delta, with its maze of coastal creeks and meandering distributaries of the Niger. East of the valley of the lower Cross River the land starts to rise into the Oban Hills, the most westerly outlier of the Cameroon Highlands system. The Oban Hills remain poorly mapped, but they are rugged, and in several places their peaks reach elevations of 900–1,000 m. Northeast of the Oban Hills and north of the Cross, but still within Nigeria, are further western outliers of the highland system, with parts of the Obudu Plateau and Sankwala Mountains rising to 1,800 m.

Much of western Cameroon is hilly, with several major peaks along a chain extending northeast from Mt. Cameroon (4,095 m), including Mt. Kupé (2,064 m), Mt. Manengouba (2,411 m), and Mt. Oku (3,011 m). Due north of Mt. Cameroon are the Rumpi Hills, which rise to 1,768 m (Mt. Rata). Mt. Oku is part of an extensive highland area around Bamenda, known as the Bamenda Highlands, which also contain the Bamboutos Mountains (2,000–2,600 m). From these highlands the Cross River drains to the west, the Benue River to the north, and the Sanaga River to the south. Although large areas of western Cameroon are above 500 m, not all of western Cameroon is upland. There are extensive lowland areas towards the coast, including the swamplands bordering the Rio del Rey, the low-lying southern sections of the Korup National Park, and the region of Douala and the lower Sanaga.

Bioko is separated from the Cameroon coast by a 37-km sea channel (many publications give an apparently erroneous figure of 32 km), a channel which reaches maximum depths of between 50 and 100 m. The island has an area of 2,017 km^2 and rugged topography, with Basilé peak (3,011 m, formerly Santa Isabel peak) dominating the northern half of the island, and the southern highlands reaching 2,261 m on the rim of

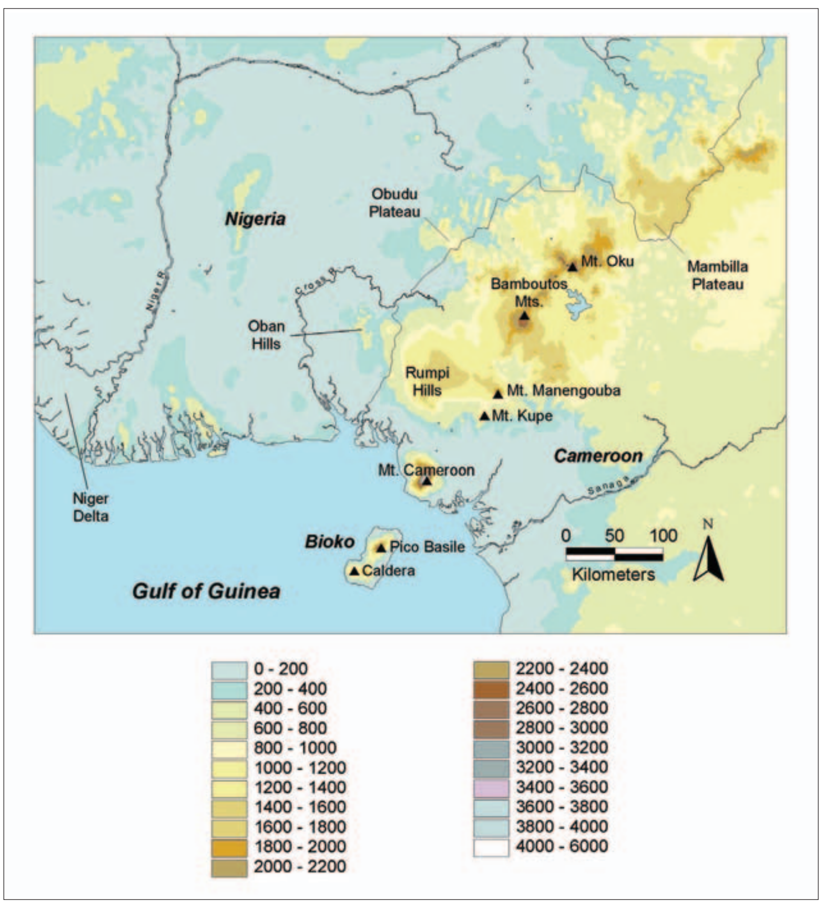

Figure 1. Elevations in the projected region in meters (data from United States Geological Survey GTOPO30 data set).

the Gran Caldera de Luba (formerly San Carlos) in the southwest and 2,009 m on the rim of the more central crater lake of Biao. Major rivers draining the southern highlands include the Ole, Osa, Moaba, and Iladyi.

Climate

Precipitation maps show that this region has the highest mean annual rainfall on the African continent. In general, total annual rainfall in the region is between 2,000 and 3,500 mm, but there is great intraregional variation related to proximity to the coast and elevation, and compounded by rain-shadow effects. For instance, annual rainfall exceeds 10,000 mm on the southern coast of Bioko, and Debundscha at the southwestern foot of Mt. Cameroon has an annual rainfall of 9,086 mm. However, Mokoko in the lowlands immediately northeast of Mt. Cameroon receives 2,844 mm of rain and Mpundu, to the east, only 2,085 mm (Fraser *et al.* 1998). Similar striking variation is shown between the annual mean rainfall of 5,460 mm at Ndian, close to the southern end of Korup National Park, and the annual mean of 3,424 mm at Mamfe, 100 km to the northeast of Korup (Gartlan *et al.* 1986, Sarmiento & Oates 2000).

Most of this region has a distinctly seasonal pattern of rainfall, related to the north-south movement of the Intertropical Convergence Zone (ITCZ). The northward movement of the ITCZ brings warm, moist air from the St. Helena Anticyclone, and between May and October there is typically heavy rainfall, with a peak between July and September (Tye 1984b, Fraser *et al.* 1998). When the ITCZ is to the south, between November and February, dry air tends to sweep down from the Sahara (the dust-laden Harmattan). Although northern locations in the region can have 4–5 months with <50 mm of monthly rainfall (e.g., Obudu town at 6º40'N, 9º09'E), the southern coasts of Bioko and Mt. Cameroon get rain in every month, and the monthly mean rainfall at Debundscha is always in excess of 100 mm (Fraser *et al.* 1998, Sarmiento & Oates 2000).

Given the proximity of the region to the equator, monthly mean temperatures in the lowlands are high and show relatively little seasonal variation. Monthly mean minimum temperatures typically vary between 22º and 24º C, and monthly maxima between 24º and 32º C. Temperatures decline with altitude, so that monthly means are 18–20º at Tole on Mt. Cameroon (elevation 700 m) and 14–16º at Dschang (elevation 1,200 m) (Tye 1984b, Fraser *et al.* 1998).

POLITICAL DIVISIONS

The region is divided politically between the Federal Republic of Nigeria, the Federal Republic of Cameroon, and the Republic of Equatorial Guinea.

The Nigerian part of the region was once part of the Eastern Region of the British-administered Federation of Nigeria, which became independent in 1960. Following political tensions in 1966–67, the Eastern Region seceded from the Nigerian federation, its military government declaring itself the Republic of Biafra. After the ensuing civil war and the reestablishment of federal rule, the east was divided into several states, which have subsequently been further subdivided. As of 2001 there were eight states between the Niger and Cross Rivers that had some of their territory in the rain forest zone: Bayelsa, Rivers, Anambra, Imo, Enugu, Abia, Ebonyi, Akwa-Ibom, and Cross River. Several of these states now have very little remaining forest cover. The largest and most easterly state, Cross River (26,590 km^2), borders Cameroon and contains by far the largest surviving area of rain forest.

The Cameroon part of the region was once divided into the United Nations trusteeship territories of Southern Cameroons (administered by Britain as part of Nigeria), and Cameroun (administered by France). Both areas had been under German administration (as Kamerun) prior to World War I. French-administered Cameroun became independent in 1960 and was joined in 1961 by the Southern Cameroons (following a plebiscite) to form the Federal Republic of Cameroon in 1961. The area of Cameroon between the Nigerian border and the Sanaga River within the rain forest zone falls within the administrative provinces of South-West (adjacent to the Nigerian border in the forest zone), North-West, l'Ouest, and Littoral.

The island of Bioko (or Bioco) is part of the Republic of Equatorial Guinea, along with the mainland territory of Río Muni (south of our study region), and the small volcanic island of Annobón, which lies along the same fault line as the Cameroon Highlands and Bioko, but is not on the continental shelf and is outside our study region. Equatorial Guinea was a Spanish colony before independence in 1968, and in colonial times Bioko was known as Fernando Poo. Although mainland Río Muni is considerably larger (at 26,003 km^2) than Bioko, the nation's capital is still at Malabo (formerly Santa Isabel) on the northern coast of Bioko.

HUMAN POPULATION, VEGETATION, AND LAND USE

Human population

In July 2003, the human populations in this region were estimated at 133.9 million for Nigeria, 15.7 million for Cameroon, and 510,000 for Equatorial Guinea (CIA, The World Factbook 2003).

With an estimated 134 million people, Nigeria is Africa's most populous country, with twice as many inhabitants as any other sub-Saharan nation. Despite its size, Nigeria is also the second most densely populated country in Africa, with an average of 140 people per square kilometer. Southeastern Nigeria is the most densely populated area of the country (where many areas support >500 people per km^2), and most of this population is concentrated between the Niger and Cross Rivers (Figure 2). Although Cameroon is less densely populated than Nigeria, some of the most densely populated areas of Cameroon (especially the Bamenda Highlands) lie within our study region. Bioko is today relatively sparsely populated, with the majority of its inhabitants located in the northern portion of the island near the capital city of Malabo.

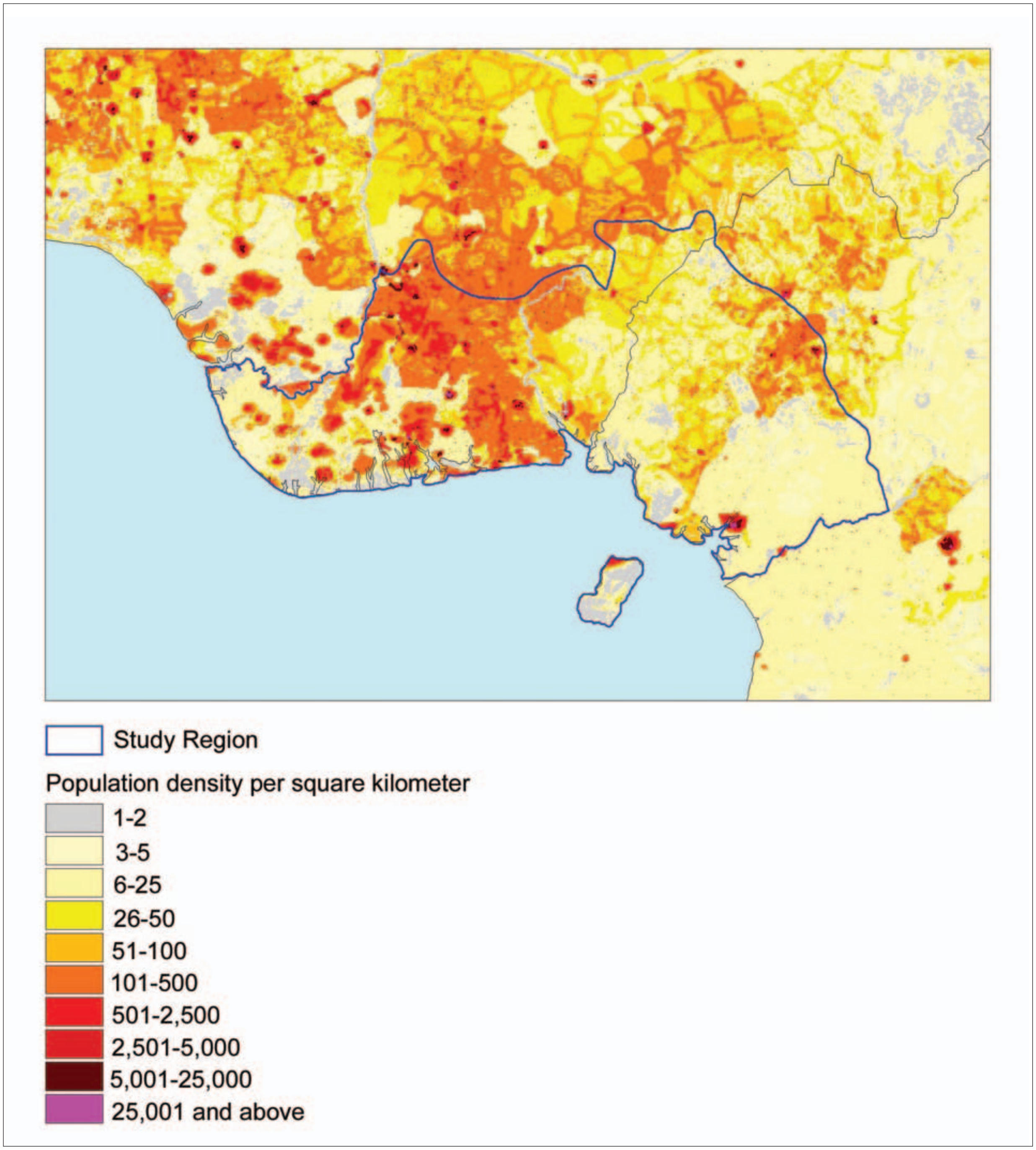

Figure 2. Estimated human population density in Nigeria and Cameroon, compared with neighboring countries (data from LandScan Global Population 1998 Database).

Forest cover

While large tracts of relatively undisturbed tropical forest are still common in Central Africa, forest cover in West Africa has become increasingly reduced and fragmented. There is considerable current debate, however, regarding the precise extent and rate of deforestation in tropical Africa. Widely available data sets for vegetation cover on a pan-African scale differ considerably in the patterns they portray. Some data sets, while generally accurate at a large scale, were highly inaccurate for our study region. For instance, the US Geological Survey Global Land Cover Classification (GLCC) misclassifies much of the southern Nigeria-Cameroon border region—an area containing the largest remaining forest block in West Africa—as cropland, grassland, and pasture. After inspecting a number of available data sets and comparing their patterns with our field observations, we decided to use the data generated by the World Conservation Monitoring Centre (WCMC) (Iremonger *et al.* 1997) as being most consistent with our observations (Figure 3).

The WCMC maps indicate that our Gulf of Guinea study region contains almost 50,000 km^2 of evergreen tropical for-

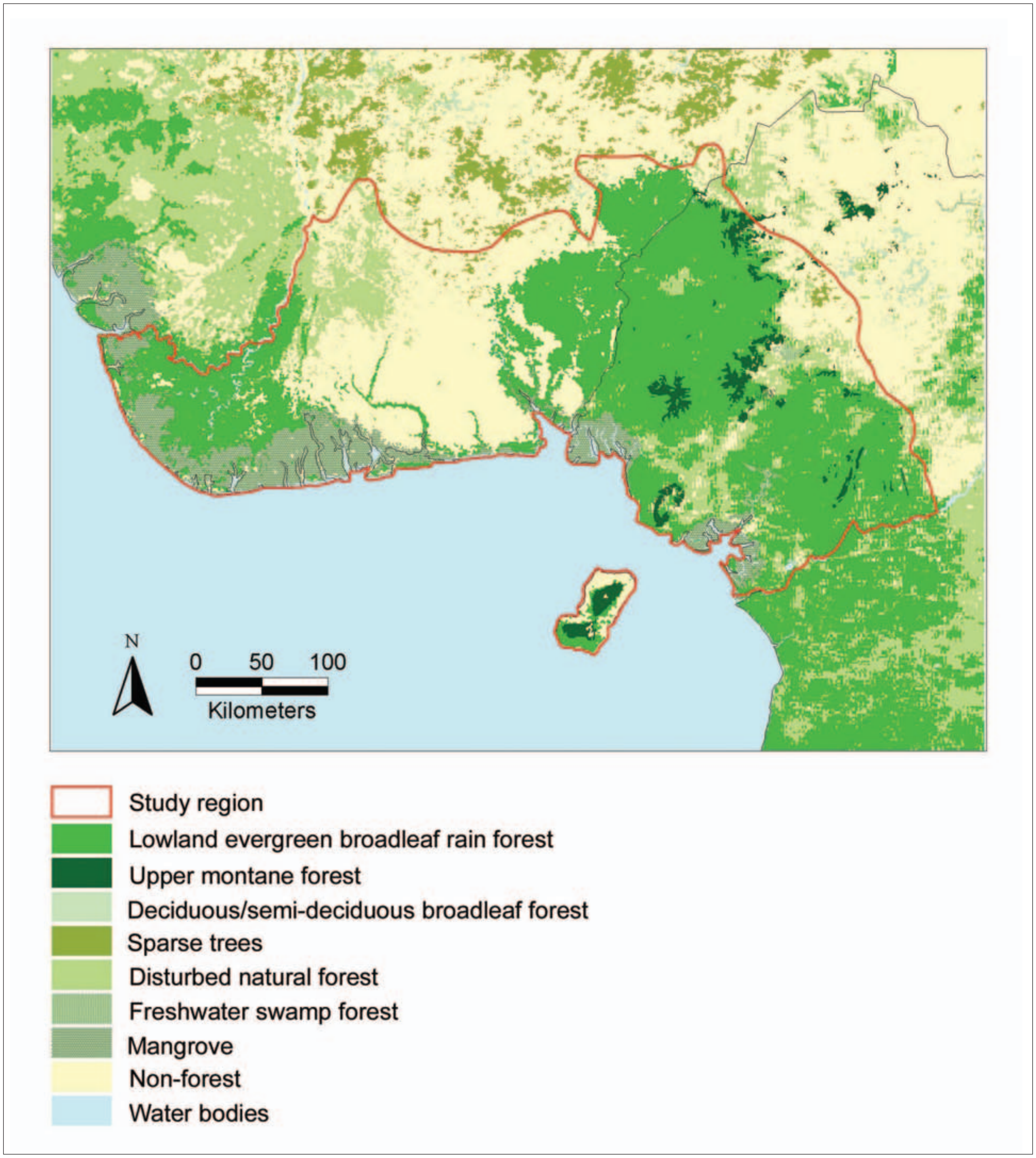

Figure 3. Land cover in the study region based on data from the World Conservation Monitoring Centre (Iremonger *et al.* 1997).

est, including approximately 3,000 km^2 of montane forest. This 50,000 km^2 represents over one third of the remaining evergreen tropical forest in West Africa. The project region also includes one of the largest—possibly the largest—remaining relatively intact blocks of contiguous forest in West Africa (approximately 26,000 km^2). This block straddles the southern portion of the Nigeria-Cameroon border and contains most of the existing protected areas in the study region.

The remaining near 50 percent of the project region consists of disturbed forest, mangrove, and non-forest, including savanna and cropland. Although the forest area still standing along the Nigeria-Cameroon border is substantial, areas around it on all sides are heavily modified by human activity. The remaining forest is being encroached upon by farmland and logging, both at its borders and from within, by enclaves of human settlements.

Landsat imagery (Figure 4) shows both substantial blocks of forest remaining and high levels of forest loss in some areas of the study region. Though more pronounced in Nigeria, the encroachment of human settlement and cultivation on forest land can be clearly seen throughout the area. The high resolution (30 m) of

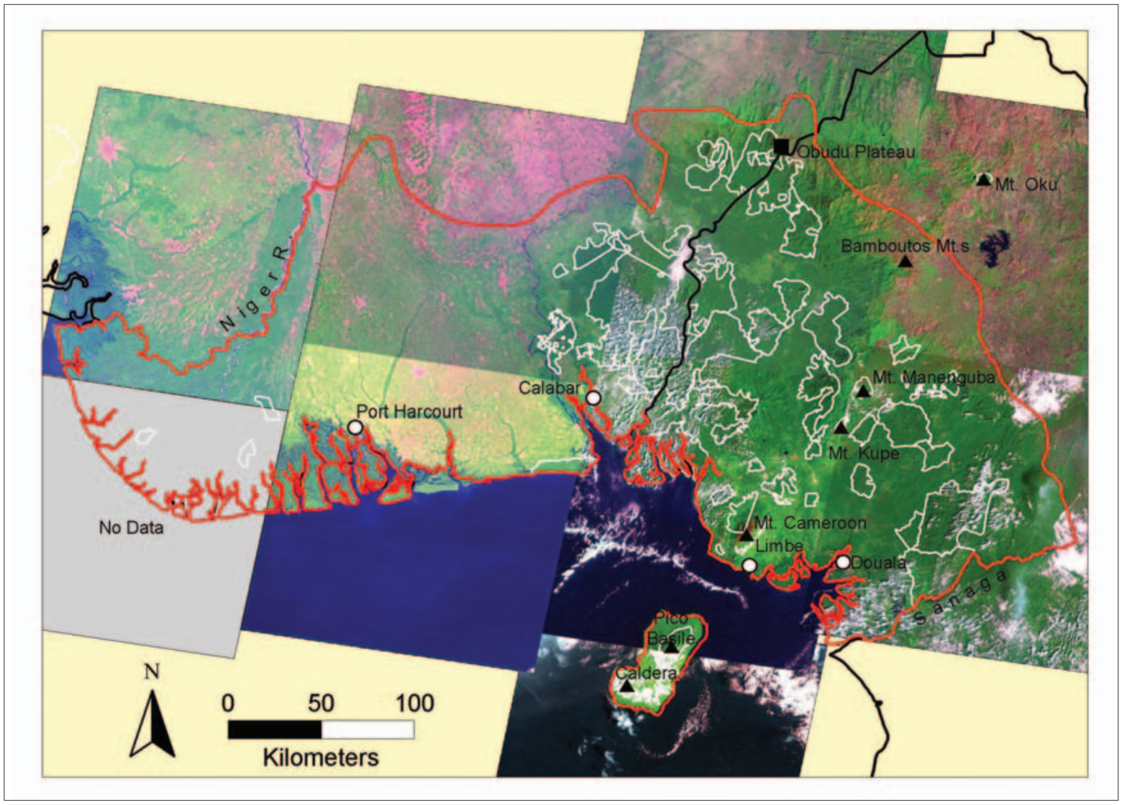

Figure 4. Satellite imagery of the project area collected by the Landsat 4 and 5 satellites (1985–87). Forested areas appear as dark green, disturbed forest and farm land as light green, and bare earth/urban areas as pink. Existing and proposed protected areas and reserves are outlined in white.

the Landsat data allows a finer-scale examination of land-cover characteristics than is possible with coarser sensors like AVHRR (1 km), upon which datasets such as the WCMC classification are based. The Landsat imagery therefore shows considerable loss of forest in areas designated as intact by the WCMC classification (even though the Landsat imagery used for Figure 4 is from 1985–87). Therefore, the WCMC dataset probably considerably overestimates the extent of continuous forest remaining in this region.

Lowland versus montane forest

The WCMC classification we have used in our land-cover mapping puts the boundary between lowland and montane forest at 1,200 m above sea level. This is, of course, a somewhat arbitrary division. Vegetation changes everywhere with elevation, but there are rarely abrupt transitions from one set of plants to another. The local climate that influences vegetation varies from place to place depending on such features as latitude, proximity to the ocean, average cloud cover, and rain-shadow effects. In general, though, as one ascends tropical mountains in the rain forest zone, tall forest gives way to forest that is lower in stature, simpler in structure, and less rich in tree species (Richards 1996).

A widely-used classification divides tropical montane forest into lower and upper montane forest (Richards 1996, Whitmore 1975). The upper montane forest is of lower stature than the lower montane forest, sometimes called "submontane" forest. The trees of the upper montane forest typically have small leaves, and epiphytes and especially bryophytes are abundant. Although the WCMC classification places the transition between lower and upper montane forest at 1,800 m, other classifications differ. Richards (1996) notes that the transition from lowland to montane forest may occur as low as 700 m, and that the transition to upper montane forest can occur at 1,100 m. For Mt. Cameroon, Richards describes lower montane forest as occurring between 1,200 and 1,800 m, but Thomas (1984), who is very familiar with the area, describes montane forest as beginning at only 800 m, with the upper montane forest commencing at 1,600 m. Cable and Cheek (1998) also set the upper limit of lowland forest at 800 m on Mount Cameroon, but refer to upper montane forest occurring between 1,800 and 2,500 m. Because of the prevalence of clouds, tropical montane forests have often been referred to as "tropical cloud forests" or "tropical montane cloud forests" (e.g., Walter 1973, Aldrich *et al.* 2000). The recent international Tropical Mountain Cloud Forest Initiative describes these forests as "frequently covered in cloud or mist" and notes that they typically occur between 1,500 and 3,000 m (Aldrich *et al.* 2000).

Despite the confusion of terms and inevitable lack of precise boundaries between them, the differences between lowland forest and the two types of montane forest are of considerable significance within our study region, for the three forest types harbor different plant and animal communities. Each is home to its own set of endemic species, and the montane forests in particular have a limited and patchy distribution and are almost everywhere under intense human pressure.

LONG-TERM HISTORY

In a review of the geology of the western Cameroon highlands, Tye (1984a) notes that many of the mountains in this area date to the Cretaceous. However, the region's orogeny appears to date to a much older tectonic feature, the junction between ancient crustal material of the West African and Congo cratons (Tye 1984a). It is apparently faulting at this junction that has led to the volcanic activity and uplifting that has produced the region's mountains.

Superimposed on this long-term tectonic activity and, along with it, influencing the history of the vegetation and fauna, has been climatic change. The historical pattern of climate change in Africa and its consequences have been matters of considerable debate. Moreau (1966) emphasized the likely effects of the Pleistocene glacial cycle on the evolution of the African fauna, and especially the montane bird fauna. Moreau envisaged the African tropical forest spreading during glaciations, whereas more recent analyses (e.g., Hamilton 1982) suggested the opposite, that at glacial maxima the climate of Africa was cooler and drier than today, and that forest was restricted to small "refuge" areas. Maley (1996) has proposed that although general forest cover was fragmented during glacial maxima, montane vegetation spread more widely at these times, allowing montane fauna and flora to migrate more readily between mountain ranges. However, West African sea cores show such wide and frequent swings in eolian dust levels over the last 2.8 million years (deMenocal 1995) that it seems unlikely that the pattern of climate change has been simple. Certainly between extremely cool, dry episodes and warm, wet episodes there must have been a range of intermediate conditions, with resultant complex impacts on vegetation and fauna.

Many deductions on the history of vegetation have been made based on animal distributions. However, a few independent data sets are available giving insights on past vegetation patterns. For instance, a recent study of geomorphological evidence on the existence of "fossil" dunes (using AVHRR radar images) suggests the advance of Saharan dunes far south in West Africa (e.g., to around Ibadan, Nigeria) earlier than the last glacial maximum at 18,000 years BP (Nichol 1999); this advance was probably at some point between 90,000 and 250,000 years BP. Nichol suggests that most of the West African rain forest would have been eliminated during such an extremely arid period. During the last glaciation there is evidence for forest growing under cool, wet conditions around Lake Barombi-Mbo in southwest Cameroon. From ca. 24,000–20,000 years BP, pollen typical of montane forest trees accumulated in this lake, which is at 350 m a.s.l. (Maley *et al.* 1990). From 20,000–14,000 years BP, there is less tree pollen and an increase in grass pollen in lake sediments, suggesting a drier climate, and after 14,000 years BP evidence appears of a more humid forest environment. However, tree pollen is present throughout. This suggests that this region contained a forest refuge at the time of the last glacial maximum, but such a refuge appears to have had forest similar to that of present-day cloud forest (Maley *et al.* 1990).

New pollen data indicate that the vegetation of the Nigeria-Cameroon border region has been even more dynamic than was suspected. Between 2,500 and 2,000 years BP, the pollen record from Barombi-Mbo indicates that primary forest trees almost completely disappeared from the area and that there was a major expansion of savanna (Maley 2002). Such a retreat of forest appears to have been widespread across Central Africa. Maley relates this event to evidence of a warming of sea surface temperature in the Gulf of Guinea at this time, which appears to have produced extended dry seasons in the forest zone. The dramatic changes in vegetation that resulted must have had major impacts on the distribution of plant and animal species that are probably reflected in present-day distribution patterns.

BIOGEOGRAPHY

The evolution of our study region's fauna and flora will have been strongly influenced by this long-term history of climate change, with its impact on the relative distribution of "lowland" and "montane" forest, and of grassland. On present evidence, it seems likely that only occasionally has vegetation similar to current montane forest spread very widely across tropical Africa. In addition to vegetation change, global fluctuations in sea level resulting from the glacial cycle will have periodically opened and closed the connection between the continental shelf island of Bioko and the mainland. The larger rivers in the region (particularly the Niger, the Cross, and the Sanaga) will also have impeded gene flow, at least for certain taxa.

Constantly changing climate and vegetation, combined with the presence of water barriers, has produced the complex array of biodiversity in our project region, and it is probably the persistence of some forest during the most arid periods of the Quaternary, and the existence of both montane and lowland forest, that has produced the high species richness and the high endemism typical of the area.

Our own special interest is in primates. A majority of the forest primates in the study region are endemic species or subspecies, restricted to some part of this area (Booth 1958, Oates 1988). Several of the monkeys are endemic to the forests between the Cross and Sanaga Rivers, and most (if not all) of the Bioko primates are subspecies endemic to the island but closely related to mainland forms (see Table 2 in Chapter 4, p. 34). Each of the primates has a slightly different distribution pattern, however, and while some are largely restricted to lowland forests, one (Preuss's guenon) is found mainly at higher elevations (see Chapter 4). Such patterns are found, with variations, across all the taxonomic groups we have studied.

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