Landscapes of West Africa

A Window on a Changing World

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A Window on a Changing World

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On October 12, 2015, the Lunar Reconnaissance Orbiter took this striking view of the Earth as it circled 134 km above Compton Crater on the Moon, near the terminator between day and night. The sharp black outline of the lunar horizon is from mountains still on the night side of the terminator, silhouetted against the lower limb of the Earth. This image is reminiscent of the iconic Earthrise photograph taken by the crew of Apollo 8 as they orbited the Moon on December 24, 1968. Many people credit that unique view of our home planet as having sparked the environmental movement that so shaped our thinking about our planet during the 1970s and beyond.

Apart from its beauty, this image of the Earth from the Moon shows the African continent quite prominently. A great amount of cloud cover characterizes the blue planet. Several large areas are, however, clear: the deserts of North Africa and the Middle East, and in the Southern Hemisphere, the drylands of southern Africa. The tropical regions of Africa's mid-section are partially covered by belts of clouds that mark the intertropical convergence zone, where the northern and southern circulation patterns merge.

Source: NASA, Lunar Reconnaissance Orbiter

Preface

Dr. Djimé Adoum

Since the 1970s, West Africa has experienced many forms of climate stress — heavy rains, floods, and periods of drought. Drought has had a particularly devastating impact on agricultural production, pastoral livelihoods, and natural ecosystems. Economic losses alone are estimated in billions of dollars.

The concerns raised by these climate stressors have translated into initiatives to combat desertification and to adapt to climate change. The Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel) and the U.S. Agency for International Development (USAID) have put in place activities to benefit the population of the Sahel and all of West Africa.

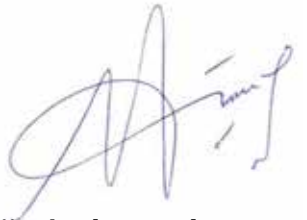
The West Africa Land Use Dynamics (LULC) Project is emblematic of this cooperation. Initiated in 1999, the LULC project has had several phases including training national experts to extract pertinent information from satellite images to characterize vegetation cover and producing tools and supporting information on land cover dynamics.

This atlas — Landscapes of West Africa: Window on a Changing World — is part of the current phase of the LULC project and provides insights into the changes occurring at national and regional levels through mapping time series data from 1975 to 2013. This work highlights landscapes that have undergone major transformations, and examines the drivers of change and their environmental and socioeconomic impacts.

The atlas showcases the accomplishments of the LULC project, and makes a case for further investment in natural resource management. Aimed at both decision-makers and the general public, the Atlas has a goal of making people aware of the changes taking place in the landscapes of the region.

Beyond raising awareness, the atlas also aims to incite action to protect the environment of West Africa and the Sahelian region. We therefore invite everyone — scientists, students, researchers, teachers, planners, managers of development or research projects, local, national and regional decision-makers, donors, members of civil society organizations, and visitors to the region — to make the most of this work.

Congratulations to the experts at CILSS, U.S. Geological Survey, USAID and the country-level teams of the LULC project for this fruitful partnership. We truly hope that this cooperation will continue and deepen, with the view of regaining the equilibrium of ecosystems. Doing so will constitute a decisive step towards realizing a green economy in West Africa, thereby enhancing the well-being of all West African people.



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FROM THE AMERICAN PEOPLE


Alex Deprez

At the core of the U.S. Agency for International Development's (USAID's) mission is a deep commitment to work as partners in fostering sustainable development. Environments that are vulnerable to changing climate patterns are often the most reliant on agriculture for food and income, and the least able to financially protect themselves or respond to disasters. As effects of climate change are felt more severely, advanced mitigation and adaptation measures are key to resilience.

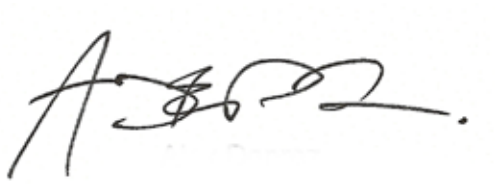
Rapid changes are occurring across West Africa's natural and human landscapes and balancing the need to preserve natural ecosystems with the need to grow more food, together with ensuring resilience in the same ecosystems, is a challenge. USAID West Africa's (USAID/WA) Environmental Threats and Opportunity Assessment and its Climate Change Vulnerability Assessment revealed that timely and accurate information, indispensable for good governance in the environmental sector, is scant and barely accessible. Mitigating climate change impacts and conserving biodiversity can support sustainable development, and prevent countries from sliding further into poverty.

USAID/WA worked in partnership with the U.S. Geological Survey (USGS) and the Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel), to analyze changes in land use and land cover in West Africa and to better understand trends over the past 40 years with the goal of improving decision-making in land management. Products derived from these analyses include maps that provide a clear record of changes and trends in three periods — 1975, 2000 and 2013 — in 17 West African countries and aggregated to the regional level.

These maps and analyses form the foundation for future landscape scenarios and contribute to a body of best practices for the re-greening of landscapes in West Africa. Application of the atlas and associated data goes beyond informing decision-making on land use planning. The time series maps provide credible information to help countries account for their carbon emissions to the United Nations Framework Convention on Climate Change and can also be used to quantify carbon emission trends in West Africa for the past 40 years.

This achievement would not have been possible without the U.S. Landsat Program. Landsat satellites have provided the longest-ever continuous global record of the Earth's surface. A partnership of the National Aeronautics and Space Administration and the USGS, the Landsat program provides image data that show the impact of human society on the planet — a crucial measure as the world's population has already surpassed seven billion people. The first Landsat satellite was launched in 1972 and now, 44 years later, Landsats 7 and 8 are continuing to provide an unbroken record of the Earth, providing critical information for monitoring, understanding and managing our resources of food, water, and forests. No other satellite program in the world comes close to providing such a long, unbroken record of geospatial information of the planet.

Knowing that these analyses will be put to use for decision making in natural resource management, I would like to thank all of the teams that worked tirelessly to produce this Landscapes of West Africa atlas. And my sincere gratitude goes to CILSS, the USGS, and the multitude of government institutions in West Africa for their commitment to completing this influential work.



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Acknowledgments

On behalf of the governments and the people of West Africa who have benefitted from the West Africa Land Use Dynamics Project, the Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS – Permanent Interstate Committee for Drought Control in the Sahel) expresses its profound gratitude to all those who have contributed to the publication of this atlas. In particular, we would like to thank:

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The national teams from across West Africa who provided valuable content for the maps and case studies.

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In Memory

Our thoughts are with three colleagues and friends who are no longer with us. All three contributed significantly to the success of the West Africa Land Use Dynamics Project, including major content contributions to this atlas:

Yendouhame John Kombaté, Responsable Suivi Evaluation et Communication, Agence Nationale de Gestion de l'Environnement, Ministère de l'Environnement, Togo;

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Introduction

Our global ecosystem is and has always been complex, dynamic, and in constant flux. Science tells us how natural forces of enormous power have shaped and reshaped Earth's surface, atmosphere, climate, and biota again and again since the planet's beginnings about 4.5 billion years ago. For most of the planet's history those environmental changes were the result of the interaction of natural processes such as geology and climate, and were described on the geological time scale in epochs spanning millions of years.

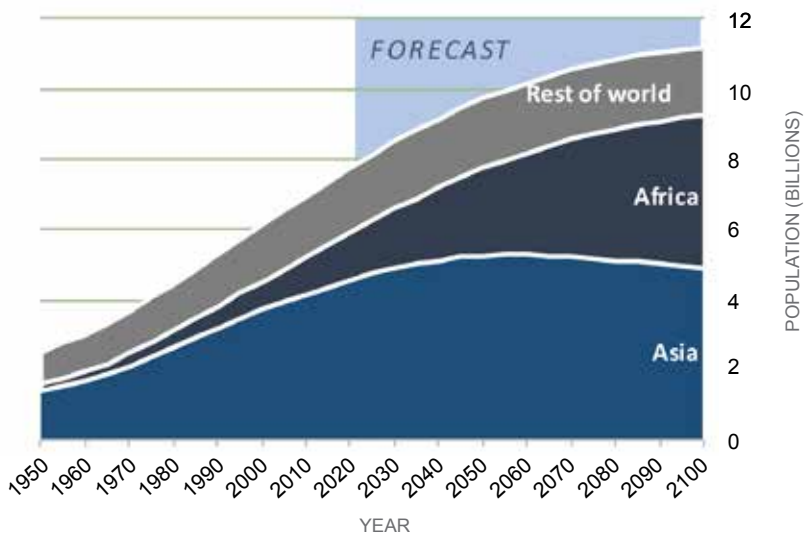
When humankind appeared on Earth around 200,000 years ago the influence of human activity on the environment must have been small and localized. The influence of scattered small groups of people on the global ecosystem would have been overwhelmed by the forces of natural systems (Steffen and others, 2007). Human population would not grow to 50 million (about 0.7 percent of the Earth's current population) for another 197,000 years. Population growth accelerated over the centuries that followed until the planet was adding more than that 50 million people every year. Our planet is now home to roughly 7.3 billion people and we are adding 1 million more people roughly every 4.8 days (US Census Bureau, 2011). Before 1950, no one on Earth had lived through a doubling of the human population, but now some people have experienced a tripling in their lifetime (Cohen, 2003).

With hunting and the use of fire, later agriculture and urbanization, and eventually the industrial revolution and modern technology, the ability of humans to shape their environment also grew exponentially. Earth scientists use the geologic time scale to describe time periods where different processes and forces shaped events in the Earth's history, such as ice ages and mass extinction events. They use periods of time they call epochs, which range from 11,700 years (the Holocene) to millions of years (the Pleistocene and Neogene). In about 2000, Earth scientists coined a new word — Anthropocene — to describe a new epoch where "the human imprint on the global environment has become so large and active that it rivals some of the great forces of nature in its impact on the functioning of the Earth system" (Steffen and others, 2011). Many in the Earth sciences believe that epoch has begun and that humankind with its vast numbers and its power to change the face of the Earth is at risk of putting the Earth system out of balance and causing the collapse of natural systems that are essential for humans to thrive, perhaps even threatening the future of all humankind.

"Mai lura da ice bashin jin yunwa" — He who takes care of trees will not suffer from hunger.

– Hausa proverb

Population growth in Africa and the rest of the world from 1950 to 2100



In 2015, the 17 countries included in this atlas are estimated to have a total population of over 369 million, representing a nearly 5-fold increase since 1950 — outstripping global population growth, which grew by 2.9 fold during the same time (UN, 2015). The young age structure of the West African population assures continued rapid population growth until 2050 and beyond. If United Nations estimates are correct the 17 countries in this atlas will grow to 835 million people by 2050; that would equate to 11.1 times as many people as lived on the same land in 1950 (UN, 2015)!

PHOTO (OPPOSITE PAGE): SUZANNE COTILLON / SGT

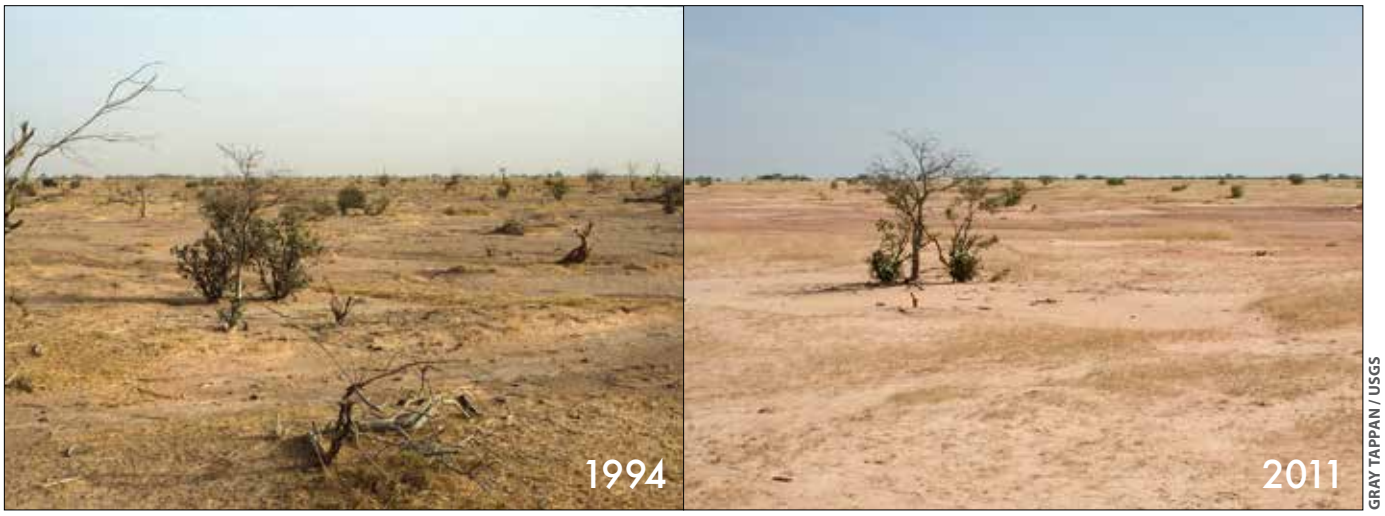
Wooded landscape fragmented by agriculture expansion in western Burkina Faso

JAMES ROWLAND / USGS

Parallel trends can be seen in the land cover changes of West Africa. With so many new families to feed, West Africa doubled the area covered by farms between 1975 and 2013. Vast areas of savanna, woodland, and forest landscape have been replaced or fragmented by cropland. At the same time villages, towns, and cities have grown in area — taking up 140 percent as much land as they had in 1975. In part to make way for those farms and settlements more than a third of the forest cover present in 1975 has been lost. In savanna and steppe landscapes of West Africa, drought, in some cases made worse by unsustainable land use practices, has degraded the vegetation cover contributing to a 47 percent increase in sandy areas (see top images pair, opposite page). The future is unpredictable, but the trends of the past four decades projected into the future would be unsustainable.

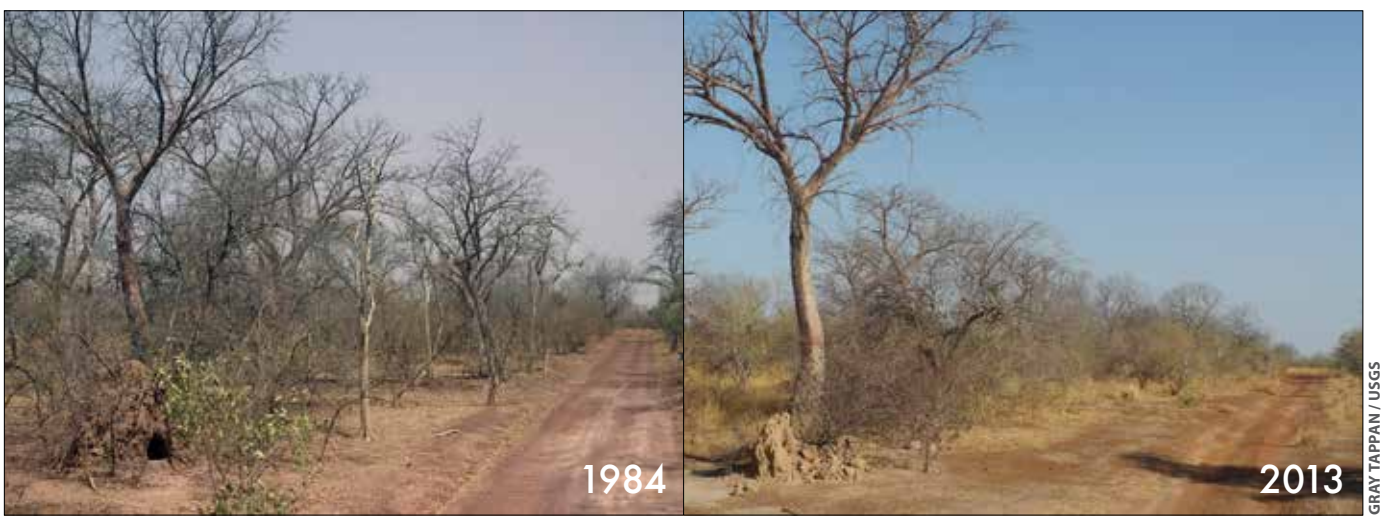
Conversion of the natural landscapes of West Africa to agriculture greatly reduces the natural biodiversity, and exposes the soil to wind and water erosion. The savanna, woodland, forest, and wetland ecosystems that are lost have some relatively tangible impacts such as the loss of natural ecosystem goods and services like wood for fuel and construction, honey, nuts, medicines, game animals, berries, and forage. There are also many important goods and services lost that are less visible such as biodiversity, carbon storage, water quality, water runoff versus infiltration, and regional climate functions.

Expansion of degraded land in the Ferlo region of Senegal



GRAY TAPPAN / USGS

Decline in vegetation cover and biodiversity in east-central Senegal

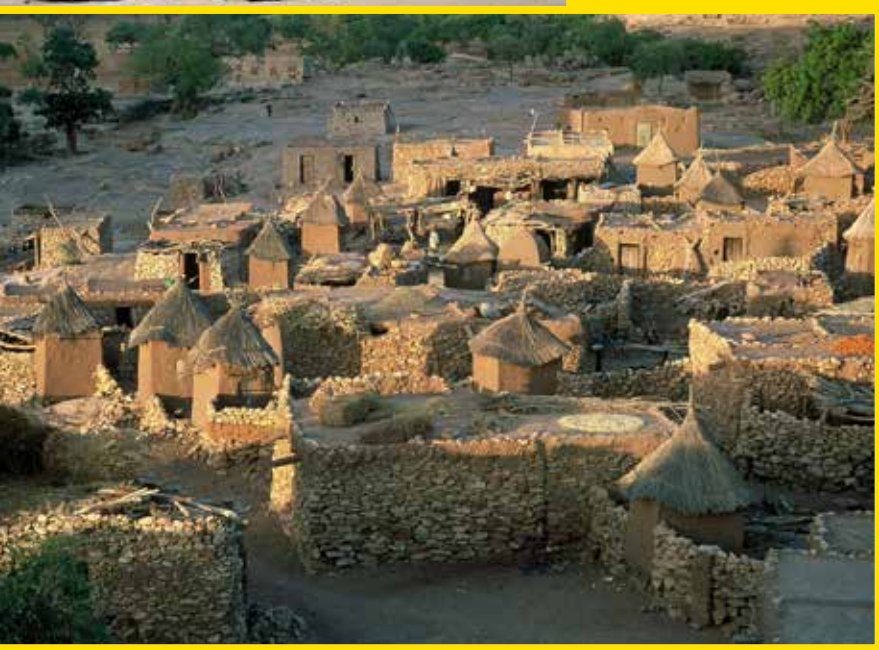


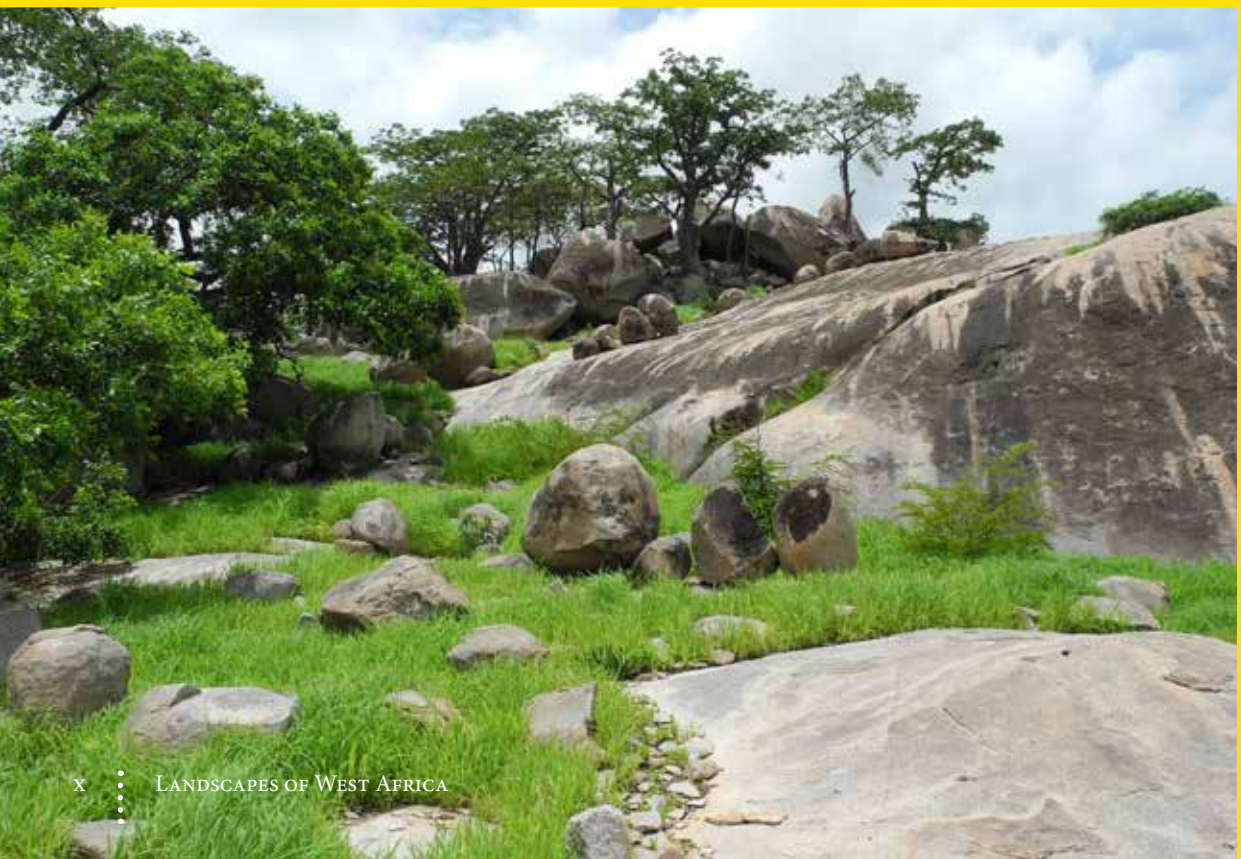
GRAY TAPPAN / USGS

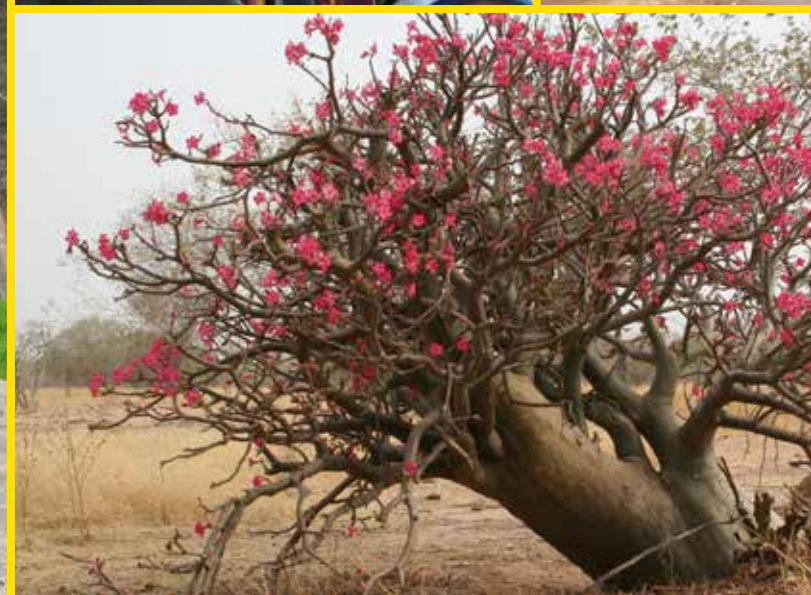
It is in the hands of today's decision makers to formulate wise, well informed choices about how to manage West Africa's land, to ensure that vital ecosystem services and agricultural productivity are able to support tomorrow's people. To make good choices the governments of West Africa need good information about the rapid changes now occurring, the causes of those changes, and the interactions occurring between climate, land use, other human activity, and the environment.

Experts from institutions in 17 countries in West Africa have partnered with the Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel), the U.S. Agency for International Development (USAID) West Africa and the U.S Geological Survey (USGS) to map changing land use and land cover and associated factors across much of West Africa through the West Africa Land Use Dynamics Project. This publication presents the results of that work. The following chapters present maps, graphs, tables, and images detailing the natural environment of these 17 countries and changes that have taken place over the past four decades.

This atlas tells a story of rapid environmental change with both hopeful and worrisome chapters. The story is told with maps and numbers detailing the rate, magnitude, and location of land cover change but also with words and images that seek to make the story more real for the people living in West Africa and around the globe. The hope is that this information helps to build a clearer picture of past and current land use and land cover in order to guide us all in making informed choices that will support the livelihoods and well-being of ours and future generations.







Chapter I

West Africa's Changing Environment

1.1 West Africa's Landscapes and Physical Geography

Physical Geography

The 8 million square kilometers and 17 countries covered by this atlas encompass a wide range of landscapes from alluvial valleys in Senegal and Ghana, sandy plains and low plateaus across the Sahel, and rolling hills of Togo to rugged mountains with summits reaching over 1,500 m in Guinea and 1,800 m in Niger. Covering approximately one quarter of Africa, West Africa contains a broad range of ecosystems, bioclimatic regions, and habitats from rain forest to desert.

West Africa can be divided internally through its natural features. Geology, relief, climate, vegetation, soils, and the responses of people to the patterns of its biophysical resources through human land uses all tend to be arranged along east-west belts. Pastoralists in northern Senegal would likely find their livelihoods more similar to those of pastoralists 3,000 km to the east in Niger than to those of someone raising cattle just 300 km south in Guinea-Bissau. Likewise the mix of crops varies more within Nigeria — from the semiarid north to the wet southern coast — than it does from one end of the West African Sahel in Senegal to the other in Chad. The most dramatic transitions in natural features and land use occur as one moves north or south across these belts we call bioclimatic regions. To better understand the geography of West Africa and how it drives land use, we briefly examine the geology, topography, hydrography, climate, and vegetation through these broad bioclimatic regions.

Geology

West Africa is remarkable for its geological variety. Like most of Africa, the region is largely composed of ancient Precambrian rocks (at least 541 million years old; the oldest rocks may be about 3 billion years old), which have been folded and fractured over hundreds of millions of years. These rocks are exposed over about one-third of West Africa and are part of the vast continental platform of Africa, which in West Africa has an average elevation of 400 m (Church, 1966). Numerous series of Precambrian rocks of various ages and their eroded surfaces provided a fairly level floor for the advance and retreat of shallow Palaeozoic seas (a major geologic era after the Precambrian, spanning about 289 million years). As these seas came and went, they deposited and eroded new material that formed the sedimentary rocks that overlay the ancient Precambrian

PHOTOS: GRAY TAPPAN/USGS; MICHIEL KUPERS; RICHARD JULIA

PHOTOS (CHAPTER 1): GRAY TAPPAN/USGS; MICHIEL KUPERS; RICHARD JULIA; MELISSA MATHIS/SGT
IMAGE (OPPOSITE PAGE): NASA BLUE MARBLE NEXT GENERATION

Physical Geography of West Africa

floor across the region. For example, a large sedimentary basin called the Senegalo-Mauritanian Basin extends across much of western Mauritania, two-thirds of Senegal, and into Guinea. It is composed of sediments deposited when the ocean covered this part of the African plate (Michel, 1973; Stancioff and others, 1986).

For most of West Africa, continental conditions have existed since the Eocene or Oligocene, that is, since the last 23 to 34 million years. Most of West Africa's mountain massifs and highlands, such as the Aïr Mountains, the Tibesti Mountains, the Adrar des Ifoghas, and the Fouta Djallon, originated as Precambrian folds (Church, 1966). Much later, volcanic activity in many of these highlands deposited additional layers of igneous rock. Volcanic outpourings have occurred throughout West Africa's geologic history, with major activity as recent as the Pliocene (2.5 to 3.6 million years ago), and even more recent activity in the Aïr and Tibesti Mountains.

During recent dry periods in the late Quaternary (0.5 to 1 million years ago), intensive weathering of sandstone formations produced much of the present day sand sheets that cover vast areas north of a line running approximately through Kano, Ouagadougou, Bamako and Dakar. These sand deposits fill in many irregularities of relief and mask much of the surface geology.

Relief

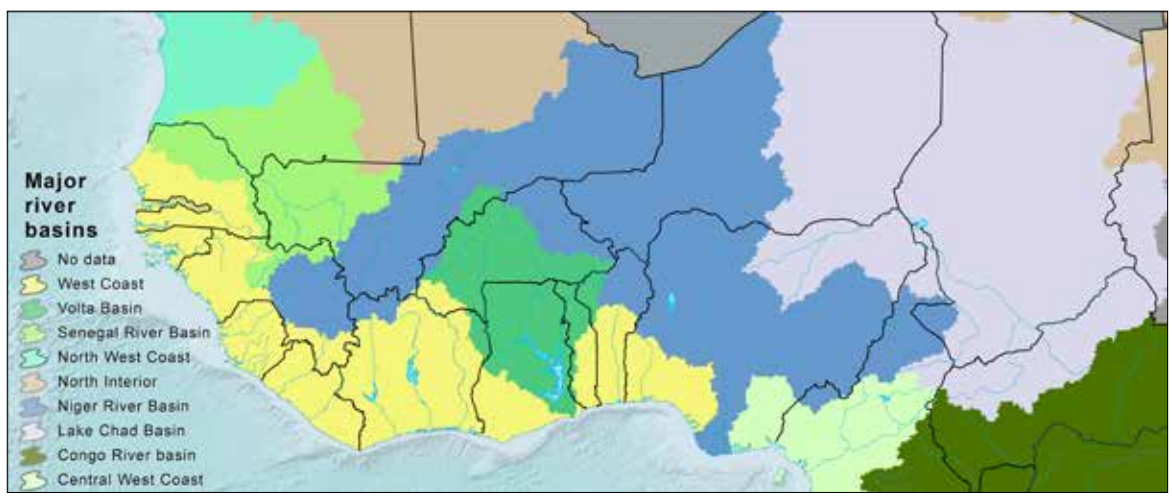
Relief on its own is not the source of great regional diversity in West Africa. For the most part, West Africa is relatively flat and low, which sets it apart from the other major regions of Africa. Nor does the relief do much to interrupt the zonal patterns and latitudinal belts of

climate and vegetation, except in the mountainous regions of the Fouta Djallon, the Guinea Highlands, the Jos Plateau, and the Aïr Mountains. In these areas, rainfall is somewhat higher than in the low plains around them.

Hydrography

Several major rivers, including the Niger — West Africa's longest river — originate in the Guinea Highlands, where rainfall is heavy. Other major rivers rise from Guinea's Fouta Djallon, including the Gambia and Senegal. The Senegal River drains a major basin — the third largest in West Africa after the Niger Basin and the Lake Chad Basin. West Africa's rivers experience great seasonal variations in river flow.

Major river basins in West Africa



(DATA SOURCE: HARVESTCHOICE, 2001)

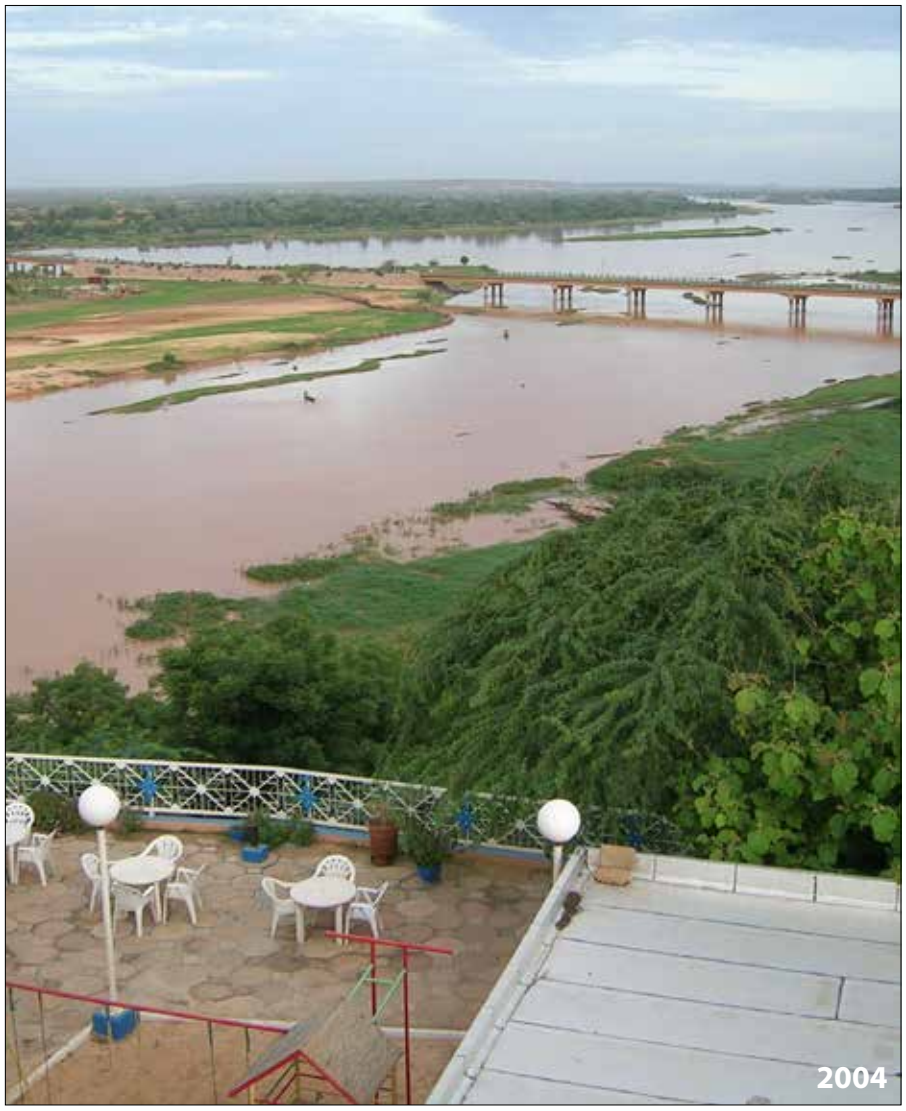
The Niger River is about 4,180 km long and passes through almost every climatic zone in West Africa. A vast inland delta has formed along its way in Mali, owing to the shallow slope of the river and sand accumulations that have obstructed its many channels. The Inland Niger Delta acts like a giant sponge, moderating the flow downstream and reducing the risk of flooding (see pages 146–147). Where the Niger arcs past Timbuktu in Mali's northern Sahel, sand accumulations push it southward. In Nigeria, the Niger River is joined by the Benue, its major tributary, which drains much of northeastern Nigeria.

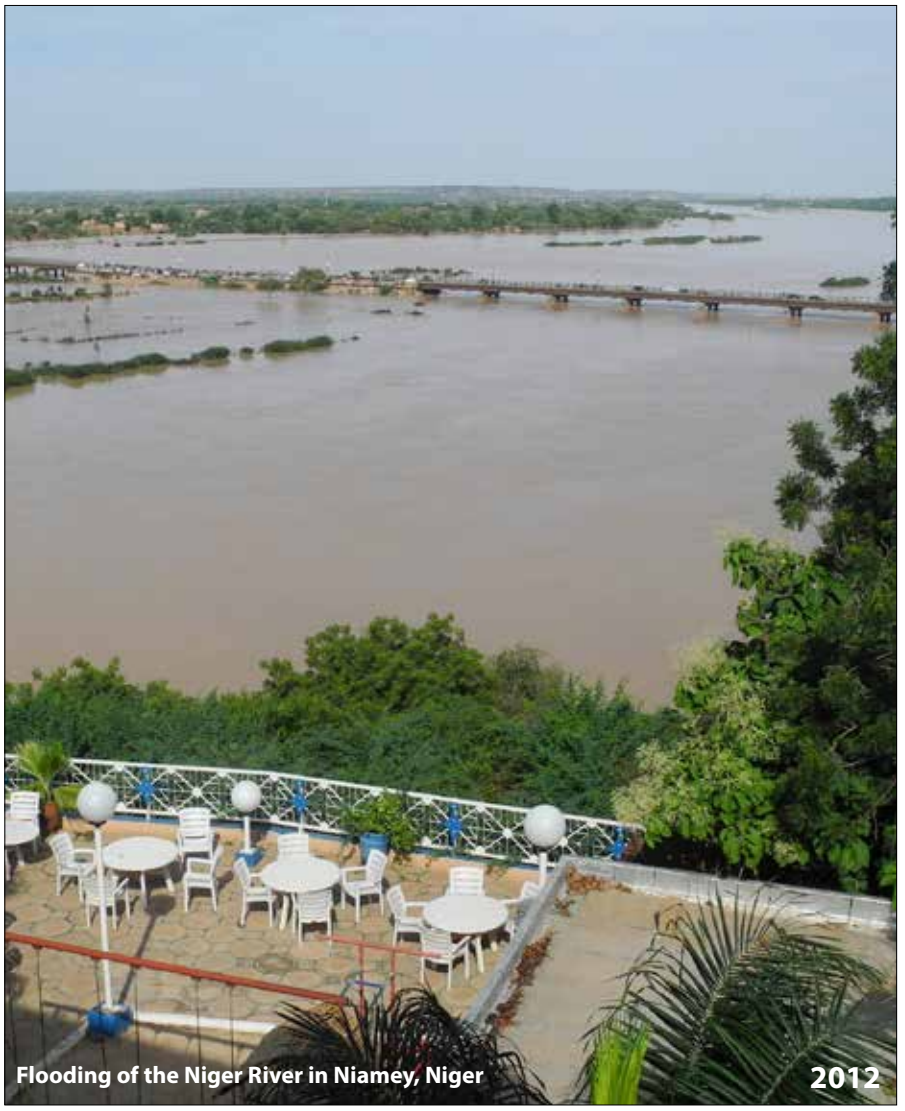
The Lake Chad Basin occupies a huge area, covering parts of Niger, most of Chad, Nigeria, Cameroon, and the Central African Republic. The catchment of the Chari and the Logone Rivers comprises the southern part of the Lake Chad Basin. They feed Lake Chad, which has shrunk to a small fraction of its 1960 size.

Many separate basins are defined by smaller rivers that drain the land between the Atlantic Ocean and the basins of the Senegal and Niger Rivers. Of these, two are worth mentioning: the Gambia, which drains central Senegal and the nation of The Gambia, and the Volta River, which starts at the confluence of the Nakanbé (White Volta) and the Mouhoun (Black Volta), and reaches into the Mossi Plateau in Burkina Faso. Ghana constructed the Akosombo Dam (completed in 1965) in a gorge where the Volta cuts through the Akwapim–Togo Range, creating the world's largest artificial lake, Lake Volta.

Climate

Most of West Africa, from the southern Sahara to the humid coastal countries, has only one rainy season, which lasts from one to six months. The area of two rainy seasons, a long one and a shorter one, is limited to the southern portions of the coastal countries from Liberia to Nigeria. The climate is related to the advance and retreat of the intertropical front — the interface between two air masses — one hot and humid and the other cool and dry. This front migrates annually north and south, following the position of the sun, with a lag of 1 to 2 months. In the winter months (December to March), there is an anticyclonic high pressure area centered over the Sahara. It drives the Harmattan, a desiccating, dusty wind that blows rather persistently from the northeast, drying out landscapes all the way to the coast. In the summer the high pressure area is replaced by a depression, bringing warm, moist winds in from the Atlantic in the southwest (from the Gulf of Guinea) (Arbonnier, 2000; Zwarts and others, 2009). Generally, the dry season lengthens and annual rainfall decreases with increasing latitude. Conversely, in the southern latitudes, rainfall increases and the dry season shortens, often to just four months (December to March). Maximum temperatures and temperature ranges also increase with latitude. In the humid south, temperatures vary little, whereas in the arid north one temperatures range from 0˚C to more than 45˚C (Church, 1966).





GRAY TAPPAN / USGS

PHOTO (OPPOSITE PAGE): MICHIEL KUPERS

From north to south — from the Sahara to the humid southern coast — West Africa can be subdivided into five broad east-west belts that characterize the climate and the vegetation. These are the bioclimatic zones known as the Saharan, Sahelian, Sudanian, Guinean, and Guineo-Congolian Regions, shown in the map on page 8. The lines between these regions represent more of a transition along a continuous ecological gradient than sharp boundaries. There is considerable variation among different authors in the definition and geographic delineation of these regions, though most use long-term rainfall averages to define the boundaries. Since long-term rainfall levels have generally decreased since the 1960s (but increased somewhat in the past two decades), some authors consider these bioclimatic regions to have shifted somewhat southward (Gonzalez, 1997). Since these regions are often referenced in this atlas, it is useful to present their general characteristics. They are presented from driest to wettest climatic regimes.

Saharan Region

The Sahara, or Saharan Region, stretches across the whole northern extent of West Africa, formed by the Sahara Desert. It consists of a variety of arid landscapes varying from sandy sheets and dune fields to gravel plains, low plateaus, and rugged mountains. Vegetation cover is sparse to absent, except in depressions, wadis, and oases, where water is present at or just below the surface. Average annual rainfall ranges from 0 to 150 mm per year.

Sahelian Region

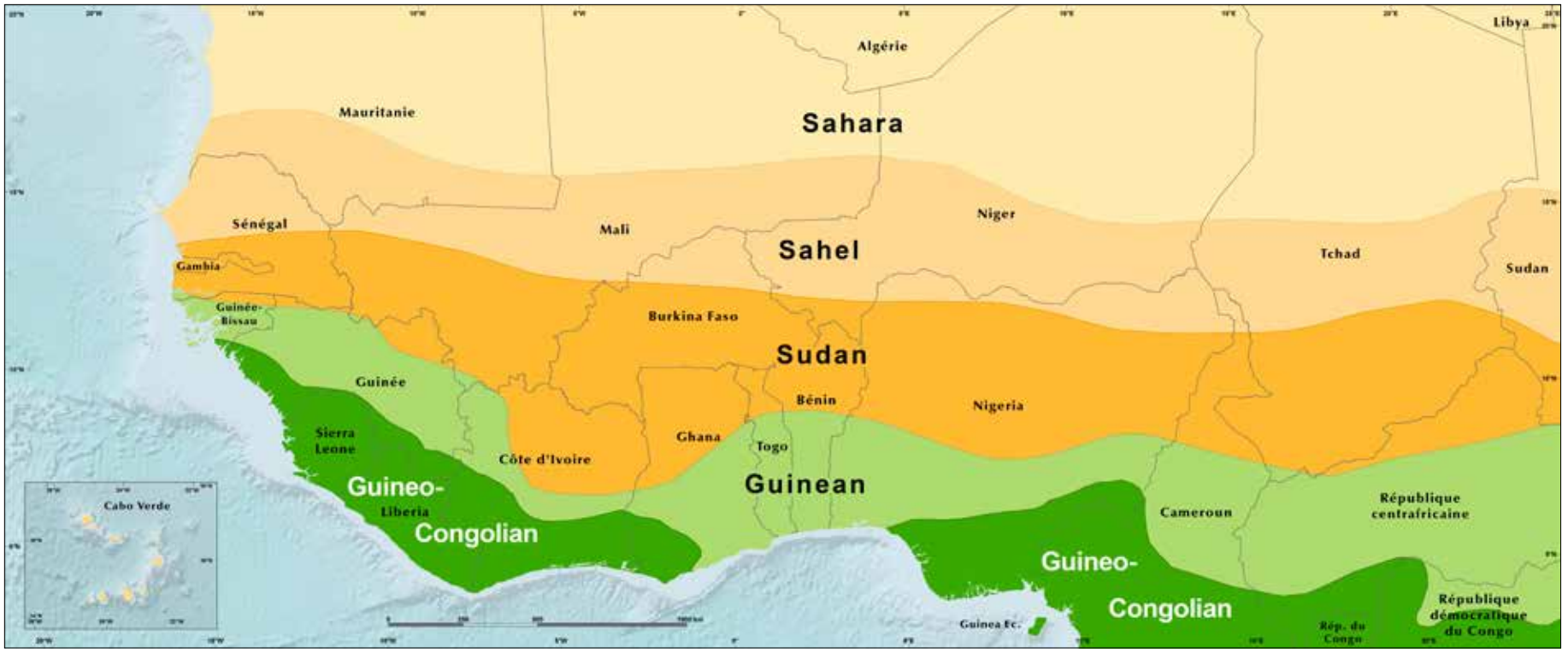
The Sahel, or Sahelian Region, is a broad semiarid belt, extending from the Atlantic Ocean to Sudan (and to the Red Sea), averaging about 350 km wide. Climatically, it is characterized by average annual rainfall between 150 and 600 mm, with great variability in amount and timing in a given year. It has an ecologically dry season of 8 to 9 months. Vegetation in the Sahel is generally characterized by open herbaceous types (steppe and short grass savanna) often mixed with woody plants. It is known for its thorny trees, particularly from the genus Acacia, and mostly annual grasses from the genera Aristida and Cenchrus. The number of woody plant species is relatively low. The present physiognomy of Sahelian vegetation results from long-term human and animal presence. Annual grass fires often sweep across its landscapes where there is ample grass cover. The Sahel is also home to countless small wetlands, like in eastern Mauritania, as well as some major ones including the Senegal Delta, the Inland Niger Delta, and the Lake Chad area.

Sudanian Region

The Sudan, or Sudanian Region, consists of a very large belt immediately south of the Sahel, with average annual rainfall between 600 and 1,200 mm and an ecologically dry season of 5 to 7 months. It is the domain of the savanna — ranging from open tree savannas to wooded savannas to open woodlands. As in the Sahel, rainfall is spread over the months when the sun is high

Temet, Niger: a wadi in the Sahara

Bioclimatic regions



(typically May to October). The short, annual grasses of the Sahel are replaced in the Sudan Region by tall, perennial grasses, mainly of the genus Andropogon.

The savannas almost always have a woody component, with trees growing among the tall grasses. There are at least 80 species of trees specific to this bioclimatic region (Aubréville, 1938). In the northern part of the Sudanian Region, tree savannas tend to dominate, whereas the southern reaches of this region typically transition into denser wooded savannas and open woodlands. Fire has been part of the region's ecology for millennia. Both natural and human-induced bush fires sweep though the savanna areas, burning up to 80 percent of their area each year. Gallery forests, with tall tree species more common in the Guinean Region to the south, follow watercourses, penetrating deep into the Sudanian Region. They are generally not affected by bush fires and often act as natural fire breaks.

Guinean Region

The Guinean Region lies immediately south of the Sudanian Region, generally defined by average annual rainfall between 1,200 and 2,200 mm. This is the domain of the seasonally wet-and-dry deciduous or semi-deciduous forest. Despite the relatively high rainfall, this region has a distinct dry season of 7 to 8 months, which distinguishes it from the Guineo-Congolian Region. The forest canopy is generally dense and closed, forming over a heterogeneous woody understory. Tree height is high, averaging 18 to 20 m. Guinean forests in their natural setting are generally not affected by bush fires. Present day landscapes of the Guinean Region are mostly altered by human activity, particularly slash-and-burn agriculture, so that the actual extent of Guinean forest is rather limited. Most of what remains has been modified by humans. The tree and wooded savannas are also extensive. Some authors consider that the forests have been replaced by "derived savanna," a mosaic of cropland, bush fallow, and secondary forest resulting from centuries of human influence (Keay, 1959). Gallery forests of varying width follow watercourses.

Guineo-Congolian Region

The Guineo-Congolian Region is the wettest in West Africa, with average annual rainfall between 2,200 and 5,000 mm. The rainfall can be distributed across most of the year, or in two rainy seasons with short drier periods between the rains. This region is split geographically into western and eastern blocks, separated by the Dahomey Gap where savanna reaches the coast. These blocks are often referred to as the Upper Guinean and Lower Guinean Forests, respectively (Church, 1966). This region is thought to have been mostly forested in the past, but today only a fraction of the land is forested. Nevertheless, the forest flora is the richest in West Africa. The forests are dense, with trees reaching over 60 m. The upper tier usually has a discontinuous canopy, towering over a lower, dense canopy. In the undergrowth, woody climbers and epiphytes are characteristic. Herbaceous ground cover may be found but can also be absent.

Sahara

Sahel

Sudan

Guinean

Guineo-Congolian

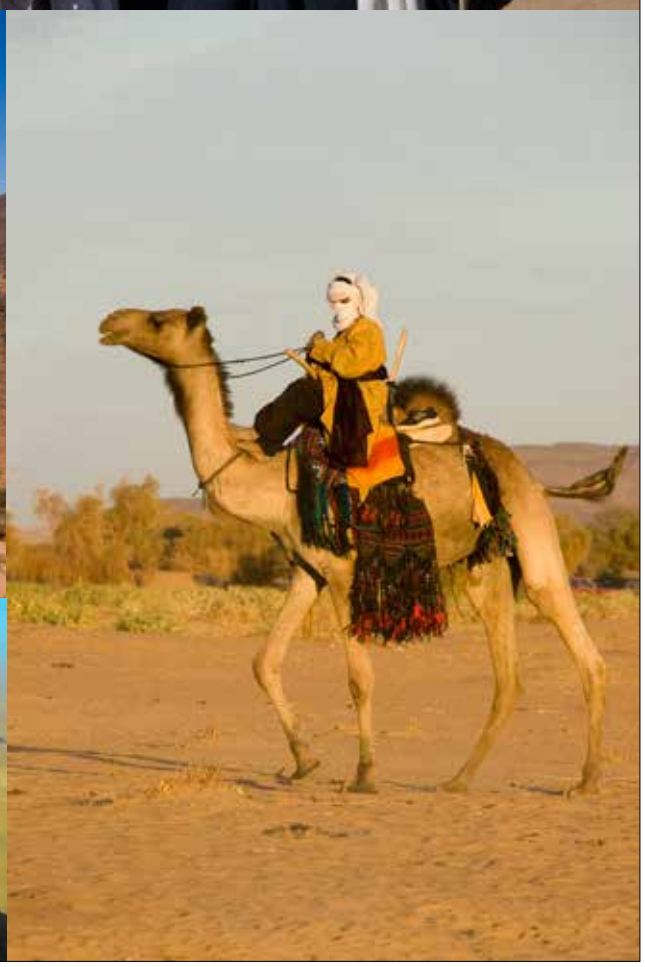
GRAY TAPPAN/USGS


ADRAR BOUS
NATIONAL NATURE RESERVE
OF THE AÏR AND TÉNÉRÉ
FADEÏ
GRÉBOUN
ATES
IZOUZAOUENE
Toussaksel
TOTAL NATURE RESERVE-
ADDAX SANCTUARY
ADRAR CHIRIET
TENERE
Iferouâne
ADRAR TAMGAK
TEKANAÏT
TCHI-N-DIRENENE
Taghmert
Arlit
TALAK
Aguelal
Agueraguer
TAKOLOKOUZET
Goundaï
TECHILI
Adrar
Egalah
Timia
Billet
MOUNT
BAGZANE
Elméki
Todghai
TAGHOUAJI
MASSIF
Tchighozérine
TERMIT-TINTOUMMA
NATURE AND CULTURAL RESERVE
Agadez
0 10 20 30 50 100km
Landsat 11 Jan 2016

Landscapes of the Sahara Desert

Among the most striking natural features of the Sahara Desert are the Aïr Mountains, rising from the sands of central Niger. These mountains, which extend over an area of 72,000 sq km — about the size of Sierra Leone — have some of the most spectacular scenery in West Africa. They evolved from a long volcanic history, with impressive peaks, the highest being Mount Bagzane (2,022 m). Most of the massif is underlain by Precambrian igneous and metamorphic rocks, characteristic of other major massifs found in North Africa (Lowman, 1968). Note the prominent round mountain masses, some over 45 km wide, seen in the Landsat image mosaic. Massive sand dunes from the Ténéré Desert, east of the Aïr, pile up against the outcrops and escarpments of the eastern side of the mountains, juxtaposing two extraordinarily beautiful landscapes.

Humans have lived among its rocks and valleys for thousands of years. The Aïr contain a treasure trove of Neolithic art, with paintings that capture a lush savanna, replete with many of the large mammals that would rival today's national parks. Deep valleys and natural springs support oasis life in the midst of these desert mountains. The village of Timia is a green gem of date palms and verdant gardens. For centuries, the Aïr have been inhabited by the Tuareg people — traditionally nomadic pastoralists who live in a vast area of the central and western Sahara. Many have settled in small towns like Timia and Iferouane, or in Agadez, the gateway to northern Niger.



MICHAEL FITZGERALD ; MICHAEL FITZGERALD ; MICHAEL FITZGERALD ; RICHARD JULIA ; RICHARD JULIA ; MICHAEL FITZGERALD

Djado, Niger

The map of ecological regions of West Africa (see pages 14–15) captures the variety and complexity of West Africa's landscapes and presents a way of organizing them into smaller units. Ecological regions, or ecoregions, are areas of relative homogeneity with respect to ecological systems involving the interrelationships of plants, animals, and their environment. Ecoregions are a holistic concept: The spatial patterns that help identify them arise from the interplay and integration of many factors — geology, geomorphology, soils, vegetation cover, climate, hydrology, and finally human modification of the land.

As some of these factors vary along gradients, not all ecoregion boundaries represent sharp or concrete differences in the landscape. Nonetheless, the identification of discrete regions of similar environmental makeup offers a helpful spatial framework for land use planning and management. Operating as integrated systems, ecoregions provide logical reporting units on a variety of biophysical and socioeconomic conditions and can be useful in many complex tasks, such as setting priorities for conservation and development, studying the impact of climate change, and assessments of carbon stocks and sequestration potential.

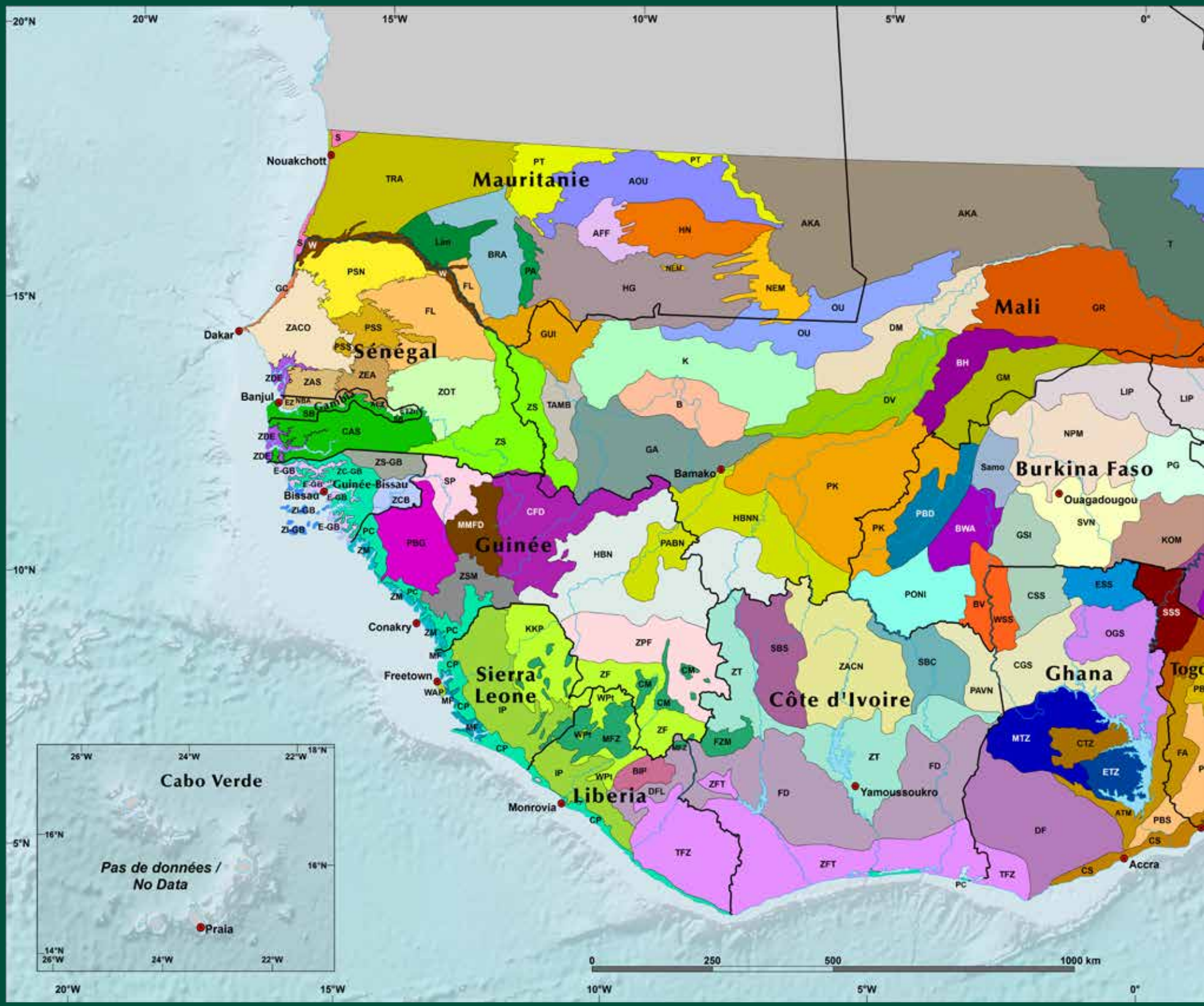
Satellite remote sensing is an effective tool for ecoregion mapping because it already integrates many biophysical and man-made elements, depicting the complex character of the land surface in image form. Landsat imagery in particular offers the ideal characteristics for delineating and classifying ecoregions from spatial patterns of the land surface at national and regional scales. Ecoregion mapping was one of the early steps in the process that culminated in mapping the land use and land cover of 17 West African countries.

The ecoregions map of West Africa was compiled from national draft maps prepared by 12 country teams during a workshop held at the AGRHYMET Regional Center in Niamey. The country teams delineated ecoregions based on visual interpretation of a Landsat image mosaic, drawing on their extensive knowledge of the biophysical and human geography of their respective countries. Their interpretation of the Landsat imagery was also supported by thematic maps of individual environmental properties (e.g., soils, geology, climate, vegetation) where available. Because the regional map was stitched together from individual national maps, ecoregion boundaries and names are not always consistent across international borders. Ecoregion names were retained in their original language.

Agricultural landscape in the commune of Kourteye, Niger

SUZANNE COTILLON / SGT

PHOTO (OPPOSITE PAGE): MICHIEL KUPERS



Ecoregions

Sénégal
- CAS Casamance
- CFD Contrefort du Fouta-Djallon
- E-GB Zone des Estuaires de Guinée-Bissau
- FL Zone Pastorale Ferrugineuse
- GC Grande Côte
- PSN Zone Pastorale Sableuse du Nord
- PSS Zone Pastorale Sableuse du Sud
- S Littoral
- W Vallée du Fleuve
- ZACO Zone Agricole du Centre-Ouest
- ZAS Zone Agricole du Saloum
- ZDE Zone des Estuaires
- ZEA Zone d'Expansion Agricole
- ZOT Zone Orientale de Transition
- ZS Zone du Socle

Gambia
- AEZ Agricultural Expansion Zone
- ETZn Eastern Transition Zone
- EZ Estuary Zone
- NBA North Bank Agricultural Zone
- SB South Bank Zone

Guinée-Bissau
- E-GB Zone des Estuaires de Guinée-Bissau
- ZCB Zone de Colline de Guinée-Bissau
- ZC-GB Zone Côtière de Guinée-Bissau
- ZI-GB Zone Insulaire de Guinée-Bissau
- ZS-GB Zone Soudanienne de Guinée-

Sierra Leone
- CP Coastal Plains
- IP Interior Plains
- KKP Koinadugu and Kono Plateaus
- MF Mangrove Forest
- MFZ Montane Forest Zone
- WAP Western Area Peninsula

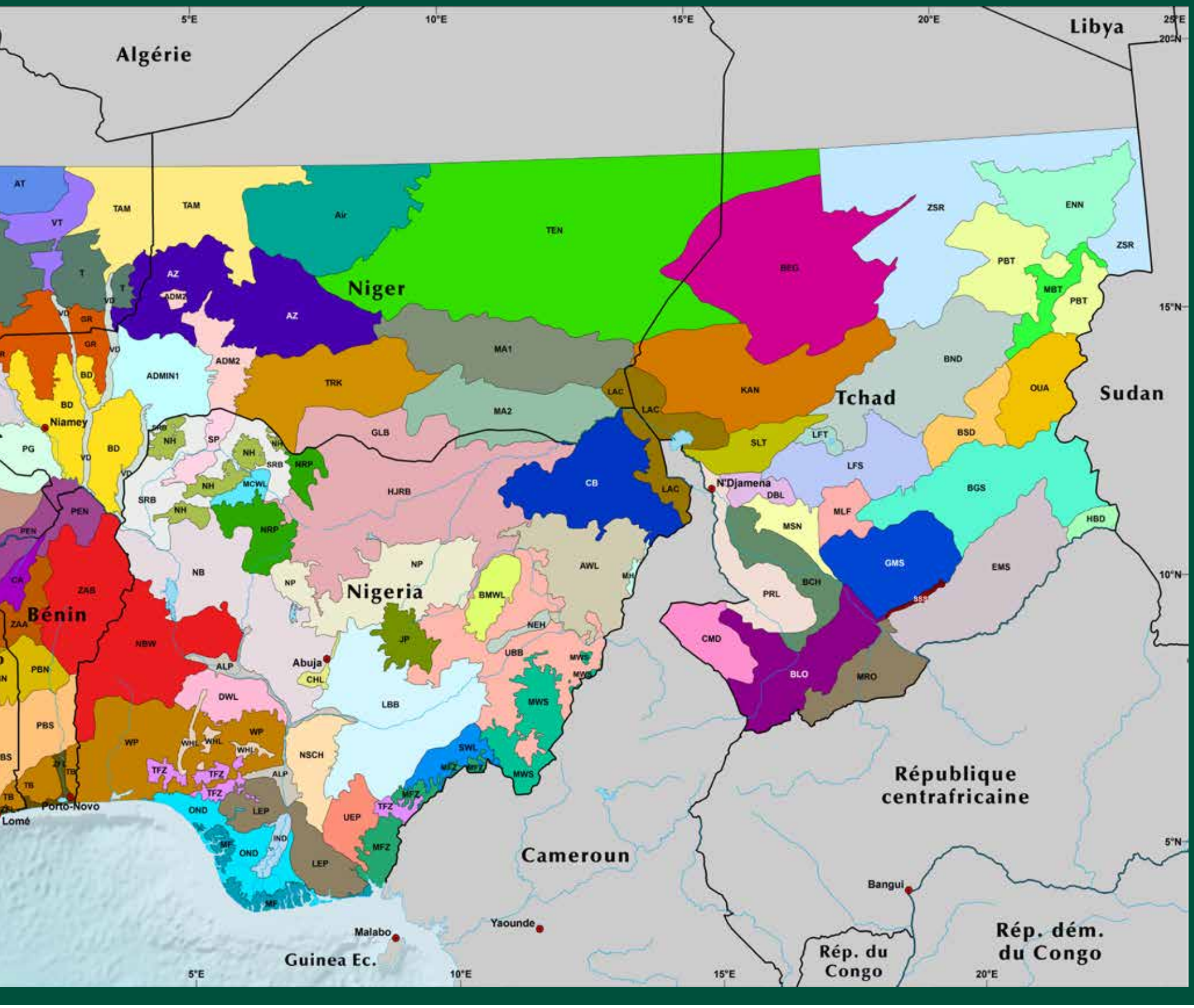
Mauritanie
- AFF Plaines de l'Affolé
- AKA Akle Azaouad
- AOU Dunes vives de l'Aouker
- BRA Plaine du Brakna
- FL Zone Pastorale Ferrugineuse
- GUI Plaines du Guidimaka
- HG Dunes attenuées du Hodh Gharbi
- HN Dunes des Hodhs - nord
- Lim Plaine limoneuse du Brakna
- NEM Collines et Depressions de Nema
- OU Ouagadou
- PA Plateaux de l'Assaba
- PT Plateaux du Tagant
- S Littoral
- TRA Trarza
- W Vallée du Fleuve

Guinée
- CFD Contrefort du Fouta-Djallon
- CM Chaines de Montagnes
- HBN Haut Bassin du Niger
- MMFD Massifs Montagneux du Fouta-Djalon
- PABN Plaines Agricoles du Bassin du Niger
- PBG Hauts Plateaux de la Basse-Guinée
- PC Plaines Côtières
- SP Socle Précambrien
- ZF Zone Forestière
- ZM Zone de Mangrove
- ZPF Zone Pré-Forestière
- ZSM Zone de Savanes et de Montagnes

Liberia
- BIP Bong Interior Plateau
- CP Coastal Plains
- DFL Degraded Forest
- IP Interior Plains
- MFZ Montane Forest Zone
- TFZ Tropical Forest Zone
- WPt Wooded Plateaus

Mali
- AKA Akle Azaouad
- AT Adrar-Timetrines
- AZ Steppe d'Azaouak
- B Bélédougou
- BH Plateau Bandiagara-Hombori
- CFD Contrefort du Fouta-Djallon
- DM Delta Mort
- DV Delta Vif
- GA Gangaran
- GM Gondo - Mondoro
- GR Gourma Malien
- GUI Plaines du Guidimaka
- HBN Haut Bassin du Niger
- HBNN Haut Bani Niger
- HG Dunes attenuées du Hodh Gharbi
- K Kaarta
- LIP Liptako Sahel
- NEM Collines et Depressions de Nema
- OU Ouagadou
- PK Plateau de Koutiala (Kenedougou)
- T Tilemsi
- TAM Azaouak-Tamesna
- TAMB Tambaoura
- VD Vallée des Dallols
- VT Vallée du Tilemsi
- ZS Zone du Socle

Côte d'Ivoire
- FD Forêt Dégradée
- FZM Forêt Montagnarde
- PAVN Plateau Agricole de la Volta Noire
- PC Plaines Côtières
- SBC Savanes du Bassin de la Comoé
- SBS Savanes du Bassin de la Sassandri
- ZACN Zone Agricole du Centre-Nord
- ZFT Zone Forestière Tropicale
- ZT Zone de Transition



Burkina Faso

- BV Plateau Lobo-Dagara
- BWA Plateau Bwa
- GM Gondo-Mondoro
- GR Gourma Malien
- GSI Plateau Gouraunsi
- KOM Plaine Kompienga-Singou
- LIP Liptako Sahel
- NPM Nord Plateau Mossi
- PBD Plateau de Bobo Dioulasso
- PEN Plaine de la Pendjari
- PG Plateau Gourmantché
- PK Plateau de Koutiala (Kenedougou)
- PONI Bassin Comoe Poni
- SVN Sud Vallée Nakambe-Nazinon
- Samo Plateau Samo

Ghana

- ATM Akwapim Togo Mountains
- CGS Closed Guinea Savanna
- CS Coastal Savanna
- CSS Central Sudan Savanna
- CTZ Central Transitional Zone
- DF Deciduous Forest
- ESS Eastern Sudan Savanna
- ETZ Eastern Transitional Zone
- MTZ Main Transitional Zone
- OGS Open Guinea Savanna
- PBS Pénéplaine bénino-togolaise sud
- TFZ Tropical Forest Zone
- WSS Western Sudan Savanna

Togo

- FA Forêt sur Atakora
- PBN Pénéplaine bénino-togolaise nord
- PBS Pénéplaine bénino-togolaise sud
- SSS Savane Soudanienne Sèche
- TB Terre de Barre
- ZAA Zone Agro-pastorale de l'Atacora
- ZFL Zone Fluvio-lagunaire

Niger

- ADM2 Zone des Plateaux d'Ader-Doutchi-Ma
- ADMIN1 Bassin d'Ader-Doutchi-Maggia
- AZ Steppe d'Azaouak
- Air Massif de l'Air
- BD Bassin des Dallols
- BEG Bassin du Bahr El Gazal ou Soro
- GLB Zone Agricole de Goulbi
- GR Gourma Malien
- KAN Kanem
- LAC Lac Tchad
- LIP Liptako Sahel
- MA1 Manga Désertique
- MA2 Manga Sahélien
- PEN Plaine de la Pendjari
- PG Plateau Gourmantché
- TAM Azaouak-Tamesna
- TEN Désert du Ténéré
- TRK Plaine de Tarka
- VD Vallée des Dallols

Bénin

- CA Chaine de l'Atacora
- PBN Pénéplaine bénino-togolaise nord
- PBS Pénéplaine bénino-togolaise sud
- PEN Plaine de la Pendjari
- TB Terre de Barre
- ZAA Zone Agro-pastorale de l'Atacora
- ZAB Zone Agro-pastorale du Borgou
- ZFL Zone Fluvio-lagunaire

Tchad

- BCH Bas Chari
- BEG Bassin du Bahr El Gazal ou Soro
- BGS Bande Guera-Salamat
- BLO Bassin du Logone
- BND Batha Nord
- BSD Batha Sud
- CMD Collines du Mayo-Dala
- DBL Dourbali
- EMS Est Moyen-Chari et Salamat
- ENN Ennedi
- GMS Sud Guera, Nord Moyen-Chari, Ouest Salamat
- HBD Hadjer Bandala
- KAN Kanem
- LAC Lac Tchad
- LFS Lac Fitri Sud-Est
- LFT Lac Fitri
- MA1 Manga Désertique
- MBT Massif du Biltine
- MLF Melfi
- MRO Maro
- MSN Massenya
- OUA Ouaddai
- PBT Plaine du Biltine
- PRL Plaines Rizicoles du Logone
- SLT Sud-est Lac Tchad
- SSS Savane Soudanienne Sèche
- TEN Désert du Ténéré
- ZSR Zone Saharienne

Nigeria

- ALP Alluvial Plains
- AWL Agricultural - Woodland
- BMWL Biu Mixed Woodlands
- CB Chad Basin
- CHL Central Highlands
- DWL Dry Woodland
- HJRB Hadejia-Jamaare River Basin
- IND Inner Niger Delta
- JP Jos Plateau
- LAC Lac Tchad
- LBB Lower Benue Basin
- LEP Lower Eastern Plains
- MA2 Manga Sahélien
- MCWL Mixed Combretaceous Woodlands
- MF Mangrove Forest
- MFZ Montane Forest Zone
- MH Mandara Highlands
- MWS Mixed Wooded Savanna
- NB Niger Basin
- NBW Niger Basin Wilderness
- NEH North East Highlands
- NH Northern Highlands
- NP Northern Central Plains
- NRP Northern Rocky Plains
- NSCH North South Central Highland
- OND Outer Niger Delta
- SP Socle Précambrien
- SRB Sokoto Rima Basin
- SWL Savanna Woodlands
- TFZ Tropical Forest Zone
- UBB Upper Benue Basin
- UEP Upper Eastern Plains
- WHL Western Highlands
- WP Western Plains

Biodiversity and Protected Areas in West Africa

GRAY TAPPAN / USGS

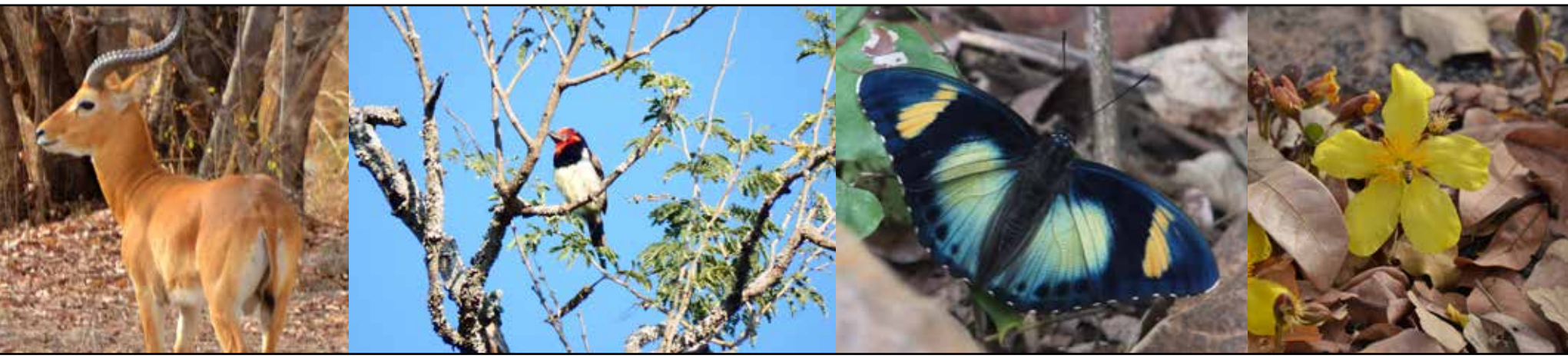
The rosewood tree (*Pterocarpus erinaceus*), rapidly disappearing from savannas and woodlands due to logging for its valuable timber.

Biological diversity, or biodiversity, refers to the variety of life. It can be measured in many ways including species richness, ecosystem complexity, and genetic variation. Biodiversity may be the greatest natural resource, as it is a source of food, fuel, medicines, clothing, building materials, clean water, tourism and many other benefits (Norse and others, 1986). Biodiversity possesses marked economic value that in many areas enables conservation to serve as a competitive form of land use (Stock, 2012).

The importance of biodiversity in West Africa is well established. The various ecosystems, ranging from dry savanna to tropical forest, provide habitats to more than 2,000 amphibian, bird and mammal species (Mallon and others, 2015). The region's tropical forest in the Upper Guinean countries is the main locus for biodiversity in the region. These lowland forests of West Africa are home to approximately 320 mammal species (which represents more than a quarter of Africa's mammals), 9,000 vascular plant species, and 785 bird species (Bakarr and others, 2004).The Upper Guinean forest is renowned for its primate diversity, with nearly 30 distinct species, and has been identified as one of Africa's most critical primate conservation areas. The West African forest ecosystem is also home to two of Africa's great apes, including remaining scattered populations of the endangered western chimpanzees and a small population of western lowland gorillas on the Nigeria-Cameroon border.

The West African countries are also home to a population of over 7,500 African elephants, although many groups reside in northern savanna habitats outside the forest ecosystems (Mallon and others, 2015). The Upper Guinean forest ecosystem of West Africa, however, is one of the most critically fragmented regions on the planet. Indeed, only 68,500 sq km, or 10 percent of its original forest cover, remains (see pages 66–67). Much of this remaining forest is exploited for timber and does not represent intact habitat. Moreover, hunting and indiscriminate trapping are prevalent throughout the forest zone, and accelerating rates of animal harvest put increasing pressure on populations of primates and forest antelopes. Similarly, hunting — whether for meat, trophies or sport — has resulted in a catastrophic decline of large mammals across the Sahel and Sahara zones in the north of the region (Durant and others, 2013; Mallon and others, 2015). The reduced prey base adversely impacts carnivore numbers, such as the African lion, across the region.

In West Africa today, most of the endangered species and highly biodiverse habitats are confined to protected areas. A total of 1,936 nationally protected areas have been identified in the region, currently covering around 9.6 percent of West Africa (see Protected Areas map pages 18–19). Approximately 90 percent of these protected areas are small and dominated by forest reserves. In addition, 53 protected areas have international designations, including 17 biosphere reserves. Protected areas vary widely in size, from less than 1 sq km to 97,300 sq km. However, large protected areas, including clusters of sites, are critical to supporting viable populations of larger species or ensuring fully-functioning, dynamic ecosystems (Mallon and others, 2015). More extensive areas or buffer zones provide connectivity between habitats, safeguard dispersal corridors between core populations and natural migration routes, and enhance resilience to the effects of climate change (Mengue-Medou, 2002). Since international borders rarely coincide with ecosystem boundaries, transboundary sites and landscapes are of great importance. These better preserve ecosystem function, show the value of managing biodiversity conservation at a sub-regional scale in spite of institutional difficulties, engage local communities, and may lead to harmonization of legislation. For instance, Diawling National Park in Mauritania and Djoudj Bird Reserve in Senegal lie on opposite sides of the Senegal River Delta, but the joint site is recognized as an International Biosphere Reserve. Similarly, the W-Arly-Pendjari complex (Benin, Burkina Faso and Niger) is a transboundary Biosphere Reserve that covers roughly 32,250 sq km and protects a highly biodiverse savanna ecosystem (see pages 20–23).



SUZANNE COTILLON/SGT; GRAY TAPPAN/USGS

Distribution of the African elephant (*Loxodonta africana*)

(DATA SOURCES: BLANC, 2008; MALLON AND OTHERS, 2015)

RICHARD JULIA

The original range of the African elephant covered all countries in West Africa, but the elephant is now extinct in at least The Gambia and Mauritania, where the last population in the Assaba Mountains disappeared in the 1980s (Mallon and others, 2015). The recent population estimate of African elephants in West Africa is about 7,500. The largest elephant population can be found in the transboundary W-Arly-Pendjari complex in Benin, Burkina Faso, and Niger. The Gourma elephant population in Mali is the most northerly in the world.

Distribution of the African lion (*Panthera leo*)

(DATA SOURCES: RIGGIO, 2011, 2013; HENSCHEL AND OTHERS, 2015; MALLON AND OTHERS, 2015)

GRAY TAPPAN / USGS

Historical data indicate that lions were formerly distributed throughout West Africa, with the exception of coastal rain forests and the interior of the Sahara Desert. Recent surveys confirm lions' presence in only six countries of the region, which means that lions have lost almost 99 percent of their former range habitat in West Africa (Henschel and others, 2015). Less than 500 lions remain in West Africa, of which less than 250 are considered "mature individuals." Around 85 percent of them occur in the W-Arly-Pendjari (WAP) complex of protected areas, shared between Burkina Faso, Niger and Benin (Henschel and others 2015). A large continuous area of distribution remains in southeastern Chad around Zakouma National Park. A small relict population survives in Niokolo-koba National Park in southeastern Senegal, as well as in Yankari and Kainji Lake National Parks in Nigeria.

Distribution of the western chimpanzee (*Pan troglodytes verus*)

(DATA SOURCES: BRNCIC AND OTHERS, 2010; HUMLE AND OTHERS, 2008; MALLON AND OTHERS, 2015; KORMOS, 2003)

KELLY BOYER ONTL

Formerly distributed in nine countries of West Africa from Senegal to Nigeria, recent surveys estimate the western chimpanzee population at 18,960–59,290 individuals. About two-thirds of the remaining representatives of this subspecies are thought to occur in Guinea, Sierra Leone and Liberia. Senegal is thought to have only a few hundred individuals remaining in the southeast of the country. However, they are likely extinct in Benin, Burkina Faso, The Gambia and Togo (Humle and others, 2008). Western chimpanzees occur in many prominent protected areas, such as Outamba-Kilimi and Gola Rain Forest National Parks (Sierra Leone), Haut Niger National Park and Nimba Reserve (Guinea), Sapo National Park (Liberia), and Taï and Comoé National Parks (Côte d'Ivoire).

Protected Areas in West Africa

Internationally designated sites

- Biosphere Reserve / Réserve de Biosphère
- Ramsar Site / Site Ramsar

Nationally designated sites

- National Park / Parc National
- Nature Reserve / Réserve Naturelle
- Faunal Reserve / Réserve de Faune
- Wildlife Sanctuary / Sanctuaire de Faune
- Forest Reserve / Forêt Classée

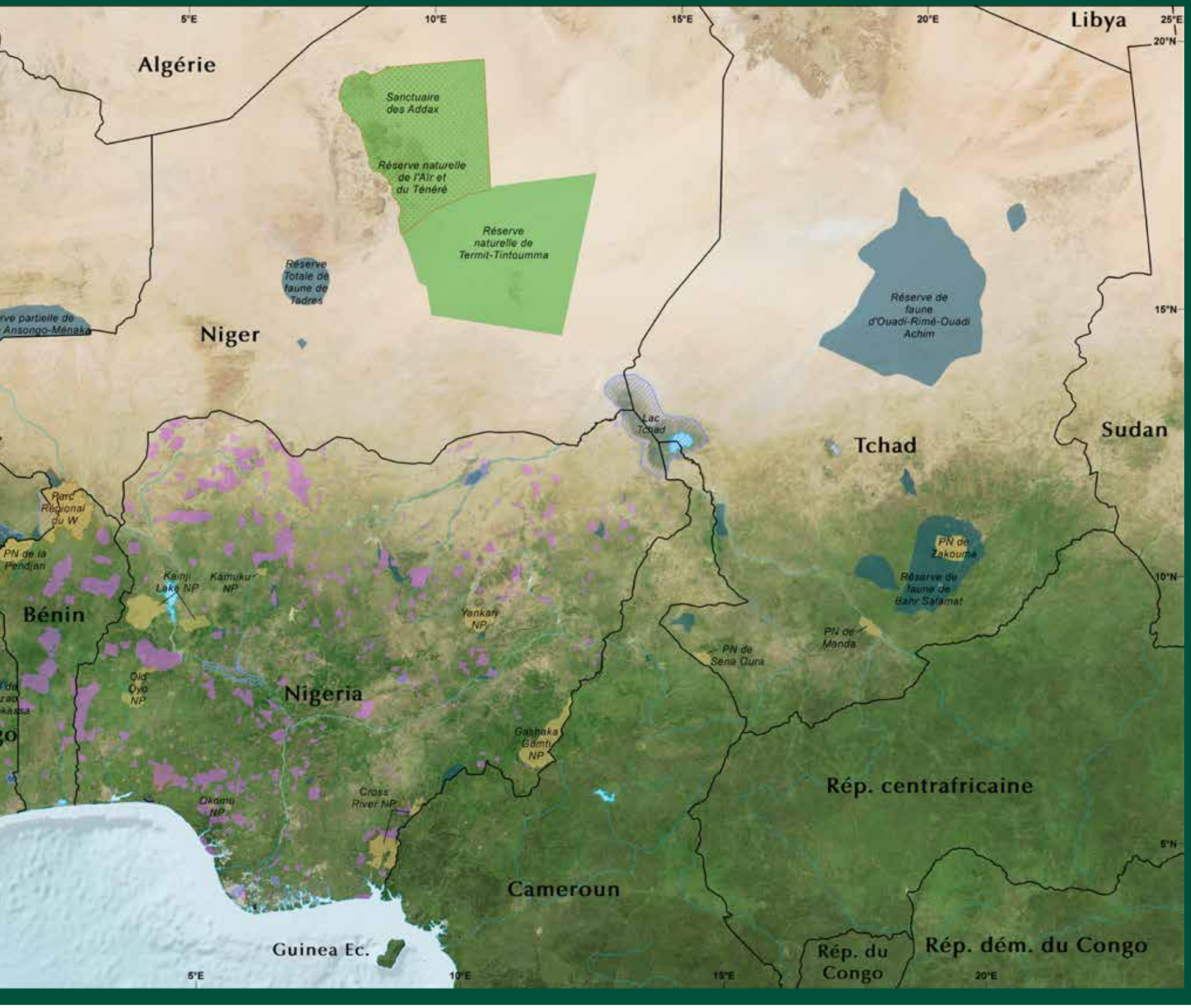
The protected areas map was compiled from the World Database on Protected Areas (WDPA) (IUCN and UNEP-WCMC, 2016). However, the WDPA database is not complete and some protected areas are not listed or are missing spatial data. Other sources were consulted in order to present an accurate and up-to-date protected areas map. Protected areas under the "Proposed" status were not included unless other sources stated they had been formally designated. Hunting zones were not included because they do not offer the level of protection inherent in other categories of protected areas.

The International Union for Conservation of Nature (IUCN) defines a protected area as, "A clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008). IUCN has also developed a system for categorizing protected areas according to their management goals and governance, but many protected areas in West Africa have not been assigned to a category and have an unclear management status. Because the 17 countries of West Africa are physically and politically diverse, the category designation and management goals of protected areas can vary greatly between countries (Mallon and others, 2015). To lessen confusion and to simplify the data for purposes of making this map, West African protected areas were grouped as follows.

Internationally designated sites

Biosphere Reserve: Sites recognized under the international UNESCO Man and the Biosphere (MAB) Programme for their ecosystem and biodiversity conservation importance. World Heritage sites that were not designated as Biosphere Reserve are not included on the map.

Ramsar site (Wetlands of International Importance): Wetlands of high conservation importance for their resources.



Nationally designated sites

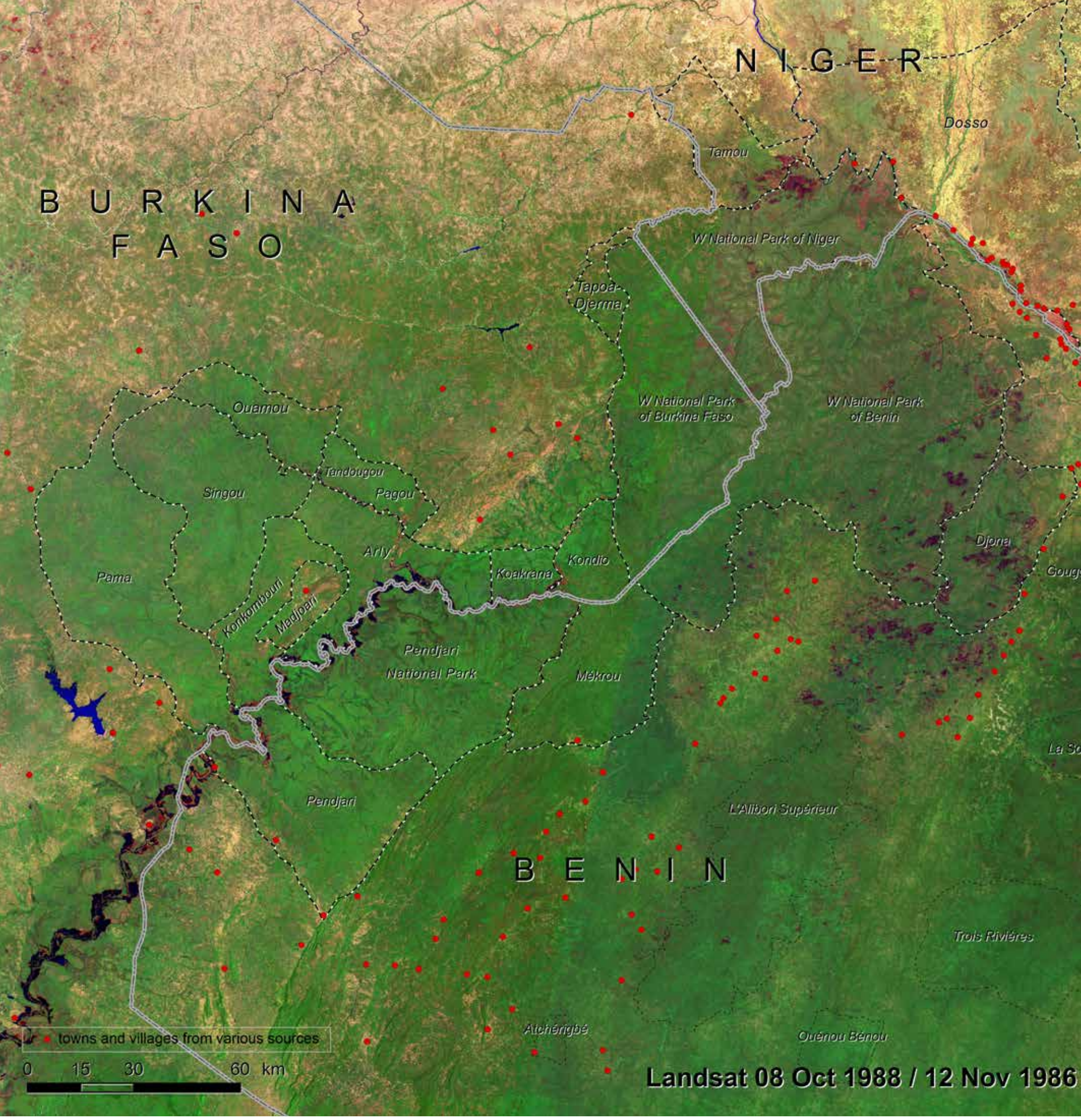
National Park: Area set aside for the protection, conservation, and propagation of natural resources of particular scientific or aesthetic interest. Prohibited activities, unless authorized by permit, include the collection or removal of any forest products, hunting, trapping, damaging natural resources, setting fire, mining, and building infrastructure (IUCN, 1992). In addition to the areas designated as "National Park," this category also includes "Natural Park" (Guinea-Bissau).

Nature Reserve: Area of importance for wildlife, habitats, or features of geological or other interest which is managed for conservation and to provide special opportunities for study or research. Management and level of protection differ by local laws. In addition to the areas designated as "Nature Reserve," this category includes the "Natural Reserve," "Wetland Reserve,""Strict Nature Reserve,""Botanical Reserve" and "Marine Community protected area."

Wildlife Sanctuary: Area set aside to assure the natural conditions necessary to protect nationally significant species or physical features of the environment where these require specific human manipulation for their perpetuation. Hunting, killing or capture of fauna is prohibited. In addition to the areas designated as "Wildlife Sanctuary," this category includes the "Game Sanctuary" and "Chimpanzee Sanctuary."

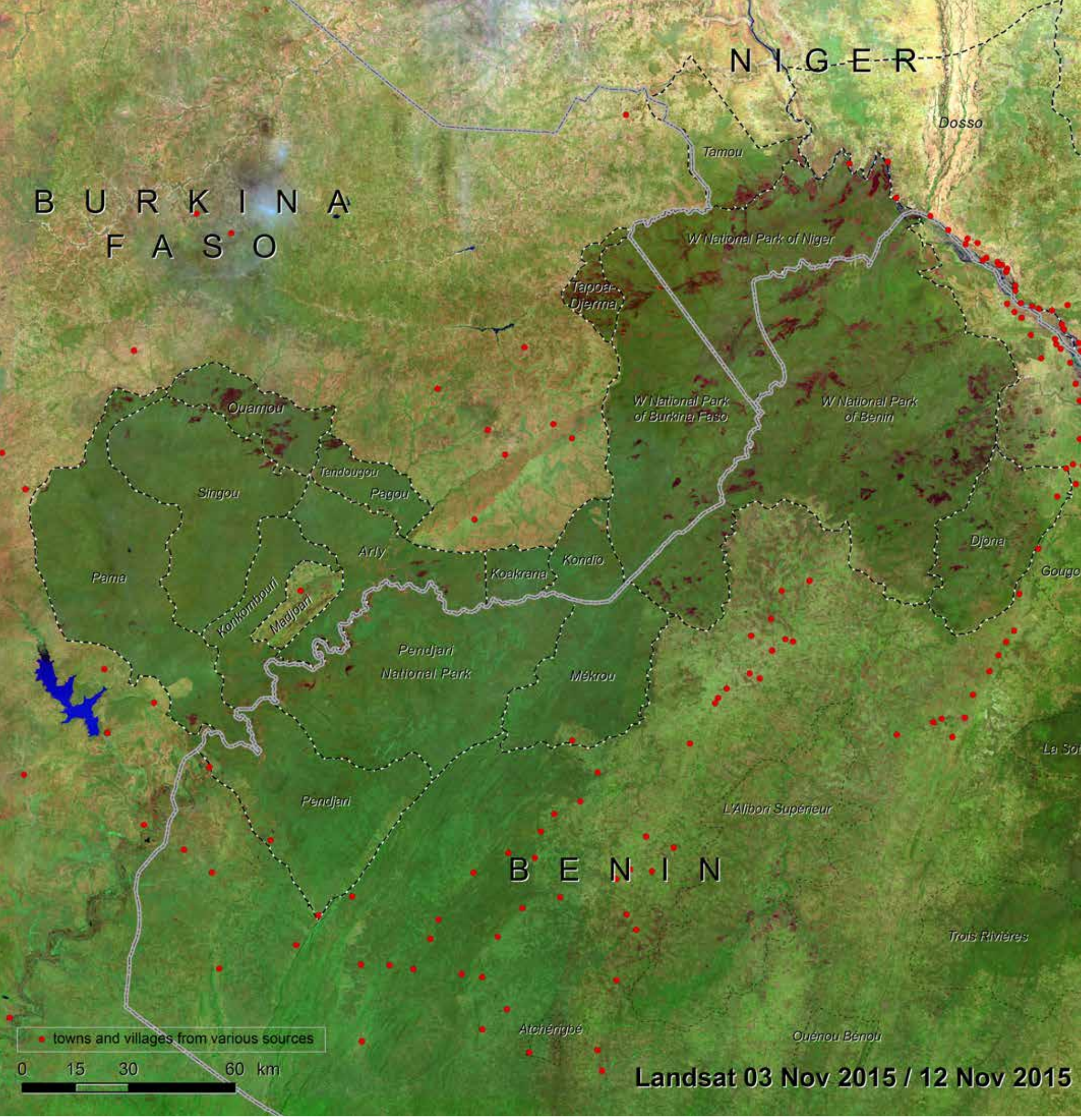
Faunal Reserve: Area established for the conservation, management and propagation of wild animal life, threatened animal or plant species, and the protection and management of its habitat. Hunting, killing or capture of fauna is regulated. In addition to the areas designated as "Faunal Reserve," this category includes the "Game Reserve," "Partial Faunal Reserve," "Bird Reserve," and "Wildlife Reserve."

Forest Reserve: Area where conservation is considered necessary to maintain the ecological equilibrium for the benefit of populations and the conservation of species recognized to be endangered. Sustainable exploitation of wood is permitted but regulated. Activities prohibited, unless authorized by permit, include farming, grazing of livestock, mining, fires, hunting, and damage to any natural resources (IUCN, 1992). In addition to the areas designated as "Forest Reserve," this category includes the "Classified Forest," "Community Forest," and "National Forest."



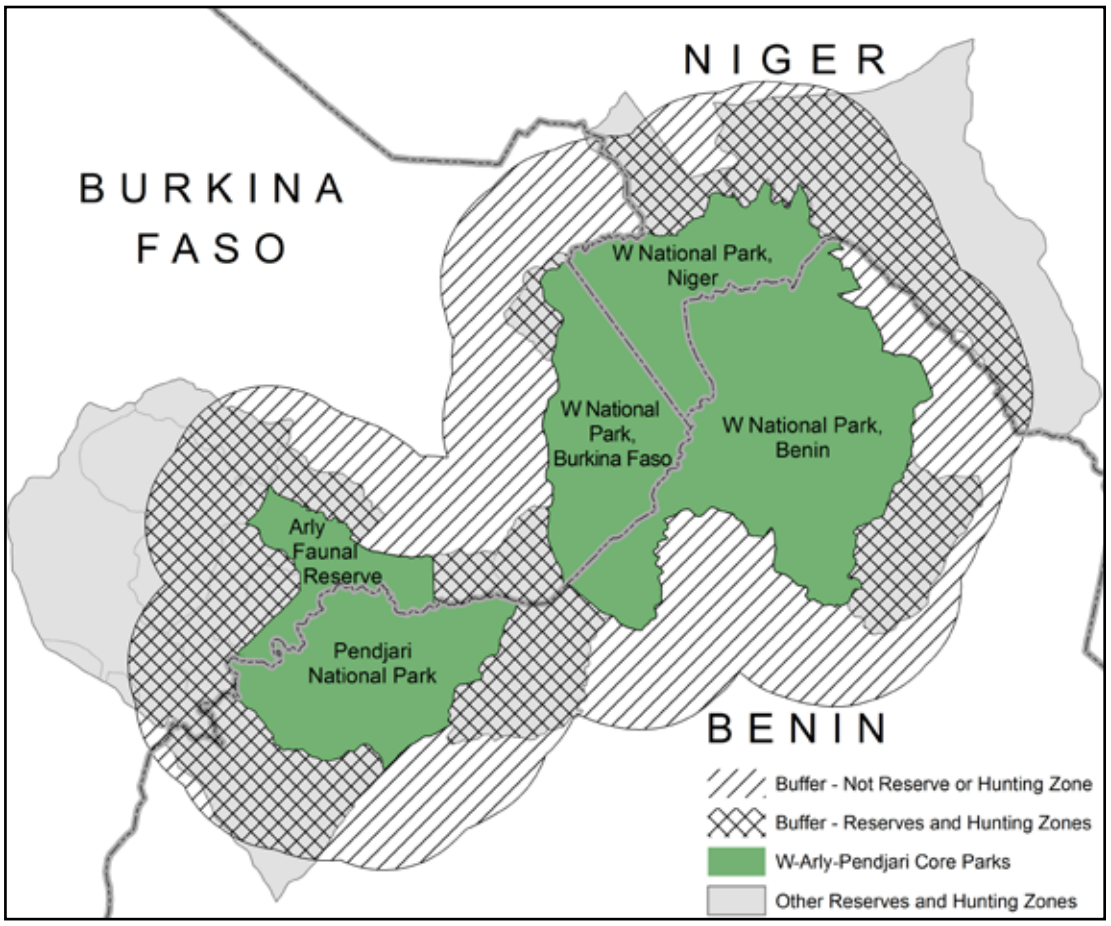
The W-Arly-Pendjari Transboundary Biosphere Reserve

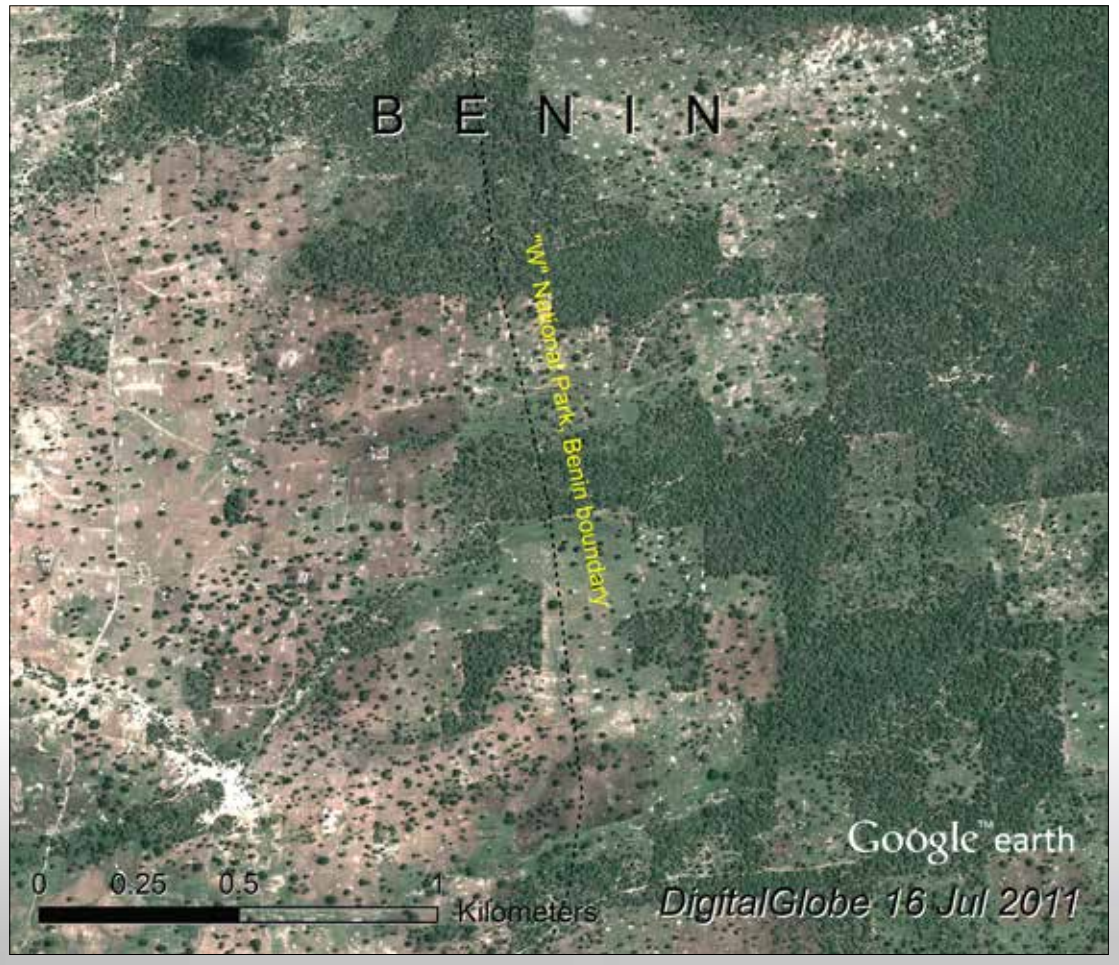
The W-Arly-Pendjari (WAP) ecological complex in West Africa is a major expanse of intact Sudano-sahelian savanna. The two core areas of the complex are the W Regional Park straddling the borders of Benin, Burkina Faso and Niger, and the Arly Total Faunal Reserve and Pendjari National Park in Burkina Faso and Benin. However, as many as 16 additional reserves, partial reserves and hunting zones surround the two core transboundary reserves, bringing the total area of the complex to roughly 32,250 sq km. While the condition and level of protection varies among the various parks and reserves, the complex nevertheless represents an extremely important contiguous body of intact West African habitat, crucial to the preservation of regional biodiversity and natural heritage (Clerici, 2007).



Between 1990 and 2015 the estimated population within a 30-km buffer surrounding all of the various designated protected areas of the complex more than doubled, from 1.67 million people to 3.52 million people (CIESIN, 2005), putting growing pressure on reserve boundaries. In the key agricultural region of northwestern Benin, food crops and a rapid expansion of cotton growing have converted the savanna landscape bordering the WAP reserve to one dominated by small holder farm fields (Kokoye and others, 2013). At the northern edge of the WAP where the Niger River forms the W shape, which gives the transboundary national park its name, dozens of new villages have appeared in recent decades. Food insecurity in the 1970s led to the decommissioning of almost half of the Tamou Total Faunal Reserve there, leading to a wave of migration to the fertile soils along the Niger floodplain. In eastern Burkina Faso, while many villages are not new (Price and others, 2002), a growing population and increasingly intense farming and cattle-raising have made the boundary between the inside and outside of the protected area a sharp unmistakable line in the 2015 satellite images.

W-Arly-Pendjari complex and surrounding buffer zones

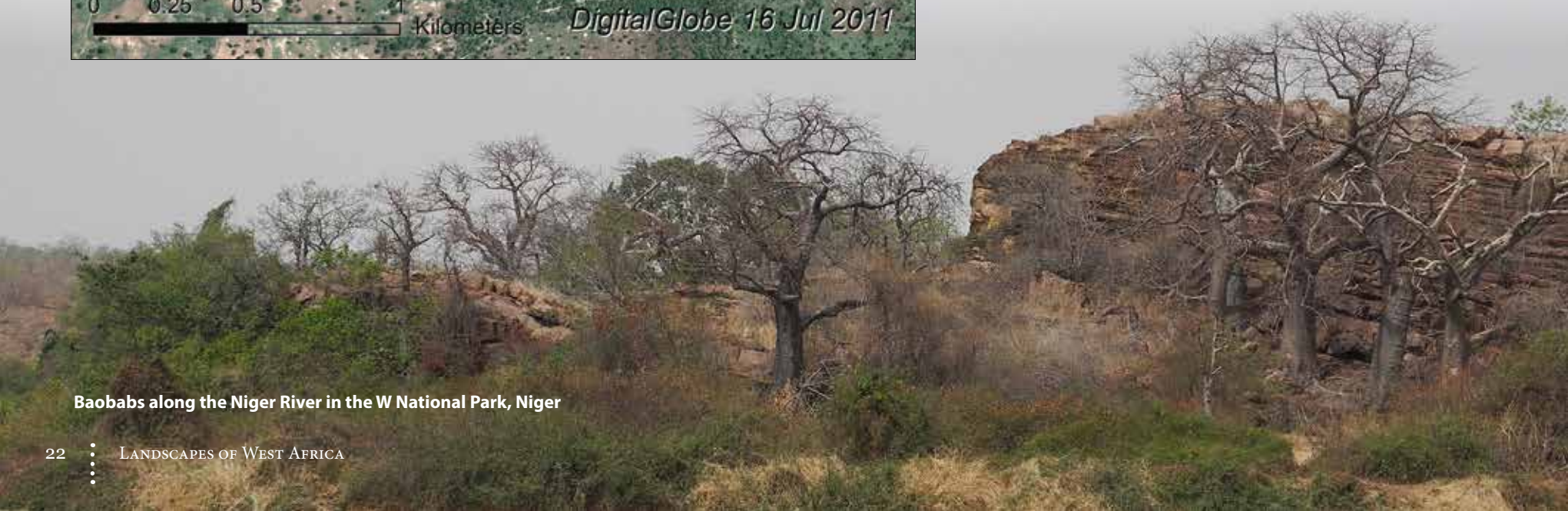




The W-Arly-Pendjari complex is recognized internationally for its important biodiversity. Pendjari National Park in Benin in 1986 and the W National Park in Niger in 1996 were designated UNESCO Biosphere Reserves. In 2002 the Benin and Burkina Faso W National Parks were added to form the W Transboundary Biosphere Reserve (TBR) (Michelot and Ouedraogo, 2009). In 2007 the wetlands of the W TBR were designated "wetlands of international importance" under the Ramsar Convention (UNESCO, 2005). The W National Parks in Niger, the W and Pendjari Parks in Benin and the Arly, W and Singou Reserves in Burkina Faso were all designated as Important Bird Areas by Birdlife International in 2001.

The size and structure of the WAP complex is unusual if not unique in West Africa where protected forests tend to be relatively small and suffer high levels of encroachment (Joppa and others, 2008). Following the biosphere reserve concept adopted by UNESCO, the WAP complex's core areas of biodiversity and intact ecosystems (green areas on the adjacent map) are protected by buffer areas and transition zones (UNESCO 1996). Nevertheless, the pressure to feed and provide livelihoods for a rapidly growing population is evident in the dramatic loss of wooded savanna and gallery forests surrounding the WAP complex's borders.

For the W-Arly-Pendjari Complex the partial reserves and hunting zones serve as buffers for much of the core's perimeter but do not completely encircle the core. Land cover maps from 1975, 2000 and 2013 (pages 44–49) show that within the core area of the three contiguous W National Parks, Pendjari National Park and the Arly Total Faunal Reserve, land cover has been very stable since 1975. Outside the core areas but within the partial reserves and hunting zones (gray with crosshatch), agriculture has increased from 8 percent in 1975 to 15 percent in 2013, while intact savanna decreased from 71



Baobabs along the Niger River in the W National Park, Niger

percent to 68 percent. In the areas outside the core and not designated as reserves or hunting zones (diagonal hatch marks), the loss of savanna was much greater. Savanna covered 70 percent of unprotected land in 1975 but just under 45 percent in 2013, as agriculture grew from 16 percent to over 44 percent.

In spite of the high levels of protection that have been established, especially for the core areas, ongoing encroachment can be seen occurring at some locations along boundaries of the reserves. The high-resolution image from July 2011 (see opposite page) shows some farm fields that have been cleared within the bounds of W National Park, Benin. Most of this sort of encroachment occurs away from the designated hunting zones and reserves, which appear to provide effective buffers for the core parks where they have been established.

It is estimated that the W Regional Park is a seasonal home to 3,800 African elephants, more than half the West African population (Clerici, 2007). Data collected from a variety of surveys taken between 2004 and 2014 sets the number of elephants in the larger complex of 19 protected areas at over 5,500 (IUCN, 2015). The WAP complex supports populations of several other large mammals including giraffe, hippopotamuses, and West African savanna buffalo, big cats such as lions, leopards, and cheetahs and a number of antelope species including roan antelope, kobs, topi, defassa waterbuck, western hartebeest, red-fronted gazelle, and oribi. The WAP complex protects hundreds of bird species, as well as many species of fish, insects and other organisms, all of which are a part of the biodiversity of this invaluable natural ecosystem.

RICHARD JULIA; RICHARD JULIA; JOAQUIM JULIA; RICHARD JULIA; SUZANNE COTILLON / SGT; GRAY TAPPAN / USGS

NASA photograph ISS042-E-244403 taken by an astronaut on board the International Space Station on February 12, 2015. This east-looking photograph includes Lake Chad, visible at left, and the Tibesti Mountains at upper right. This photo was modified to include a NASA artist's rendition of Landsat 8 in orbit.