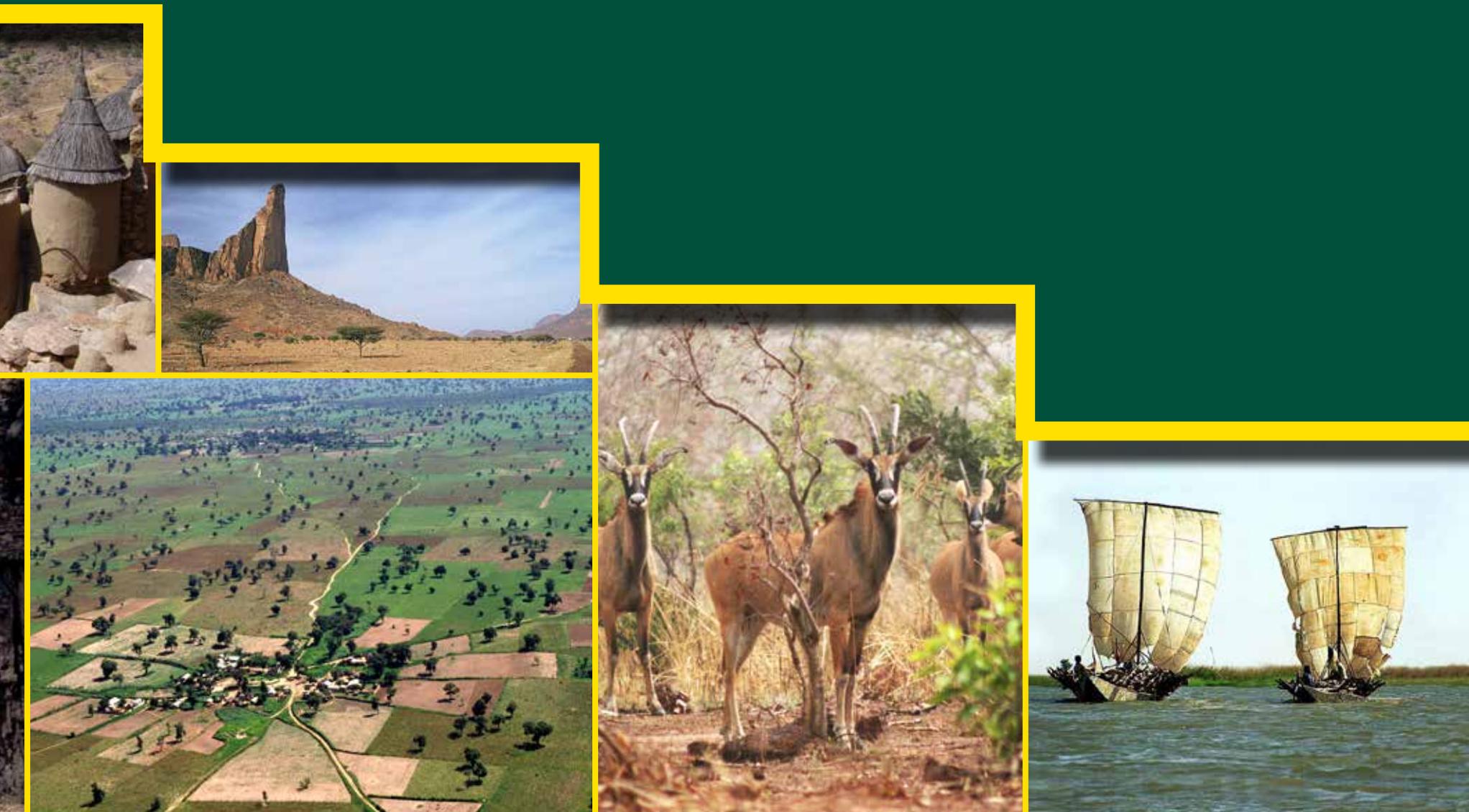


Landscapes of West Africa

A WINDOW ON A CHANGING WORLD



Landscapes of West Africa

A WINDOW ON A CHANGING WORLD



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science for 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.





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.

A handwritten signature in blue ink, appearing to read 'Djimé Adoum'.

Djimé Adoum, Ph.D,
Executive Secretary
CILSS
Ouagadougou, Burkina Faso



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FROM THE AMERICAN PEOPLE

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.

Alex Deprez
Regional Mission Director
USAID/West Africa
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Alex Deprez



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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In Memory

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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

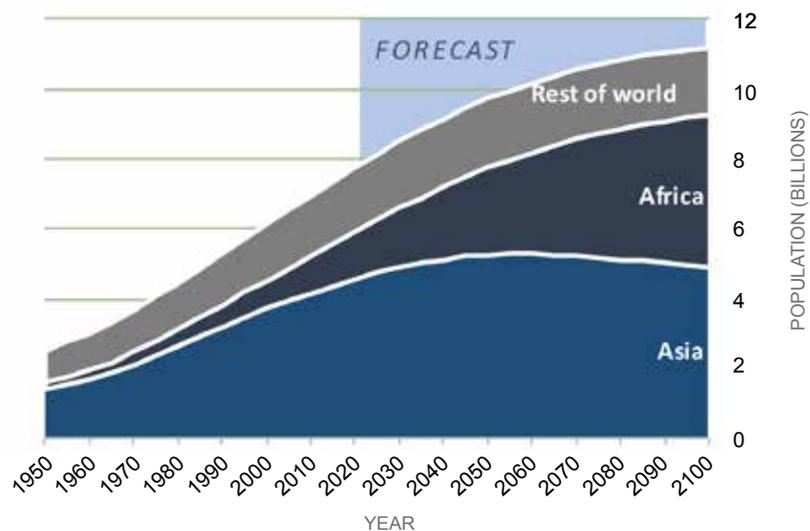
the collapse of natural systems that are essential for humans to thrive, perhaps even threatening the future of all humankind.

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)!

“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



Wooded landscape fragmented by agriculture expansion in western Burkina Faso



JAMES ROWLAND / USGS

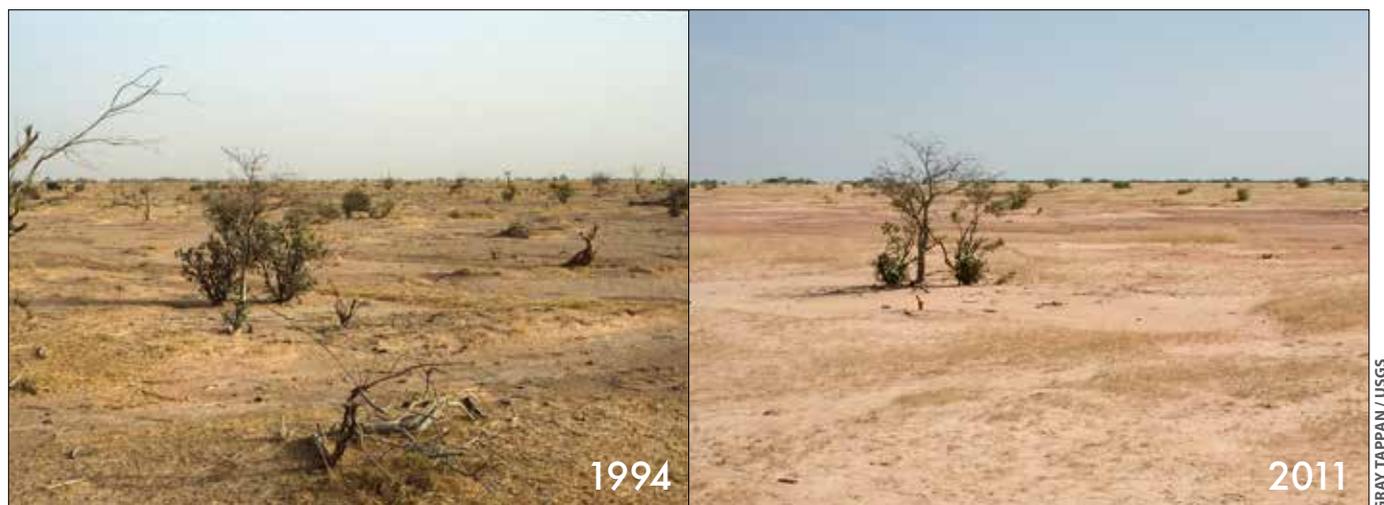
Parallel trends can be seen in the land cover changes of West Africa. With so many new families to feed, West Africa doubled the area covered by farms between 1975 and 2013. Vast areas of savanna, woodland, and forest landscape have been replaced or fragmented by cropland. At the same time villages, 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.

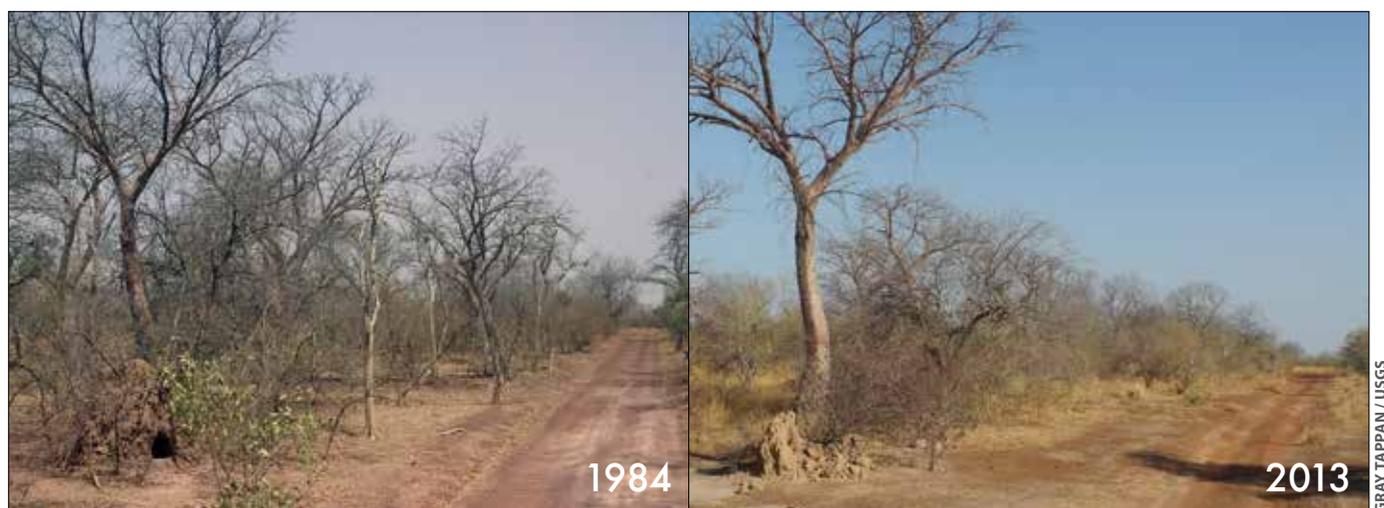
Conversion of the natural landscapes of West Africa to agriculture greatly reduces the natural biodiversity, and exposes the soil to wind and water erosion. The savanna, woodland, forest, and wetland ecosystems that are lost have some relatively tangible impacts such as the loss of natural ecosystem 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



Decline in vegetation cover and biodiversity in east-central Senegal



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.

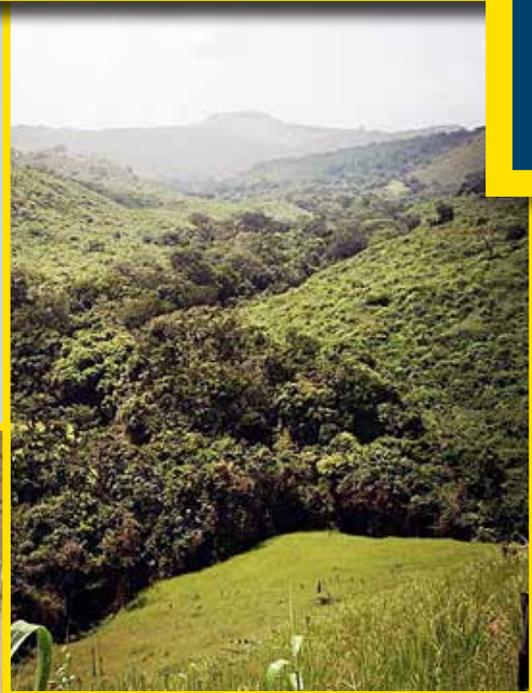
Experts from institutions in 17 countries in West Africa have partnered with the Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel), the U.S. Agency for International Development (USAID) West Africa and the U.S 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.





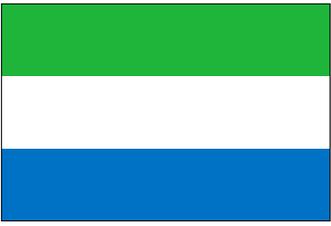


Chapter

III

Country Profiles, Land Use and Land Cover, and Trends





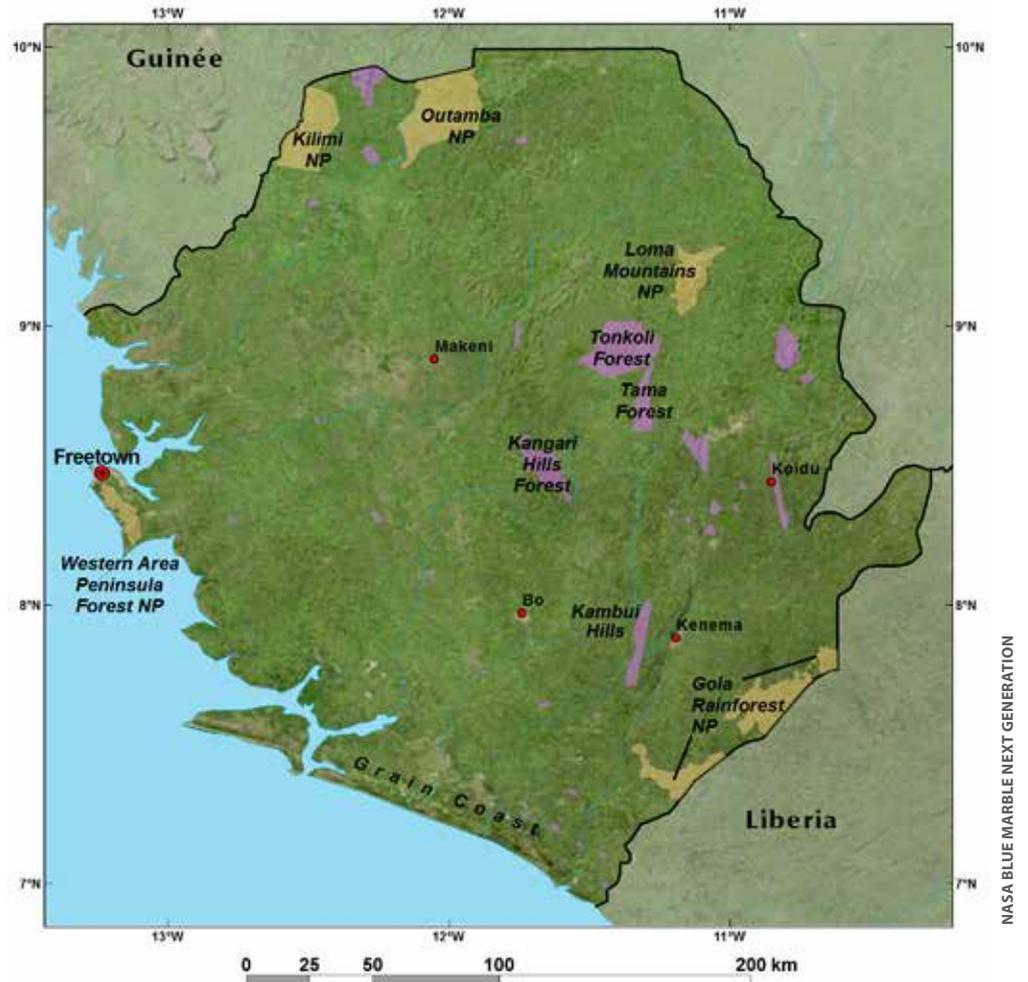
Republic of

Sierra Leone

Total Surface Area: 71,740 km²

Estimated Population in 2013: 6,179,000

Sierra Leone has a special significance in the history of the transatlantic slave trade. Its capital, Freetown, was founded in 1787 as a home for repatriated former slaves from London and the Americas. Sitting on a coastal peninsula, the city overlooks the Sierra Leone Harbor, the world's third largest natural harbor. The country is characterized by a humid tropical climate. Annual rainfall ranges from 1,900 mm in the northwest to over 4,000 mm on the coast, which makes Sierra Leone the wettest country in West Africa. Its landscape includes a flat coastal zone with fringing mangrove swamps. A large plain extends inland that transitions into wooded hills and an interior plateau interspersed with forested high mountains in the east. The country's vegetation is highly complex and characterized by a matrix of patches of forest, woodland, savannas, and cropland. Sierra Leone's economy stems from its rich natural resources but is still recovering from a civil war that destroyed most institutions before ending in the early 2000s. Agriculture, as the primary occupation, employs two-thirds of the labor force and accounts for 66.8 percent of the country's gross domestic product (GDP) (CIA, 2013). Sierra Leone also possesses substantial mineral resources, particularly iron ore, and has relied on mining for its economic base in recent years. In addition, the country is among the largest producers of titanium and bauxite, a major producer of gold, and in the top ten diamond-producing nations.



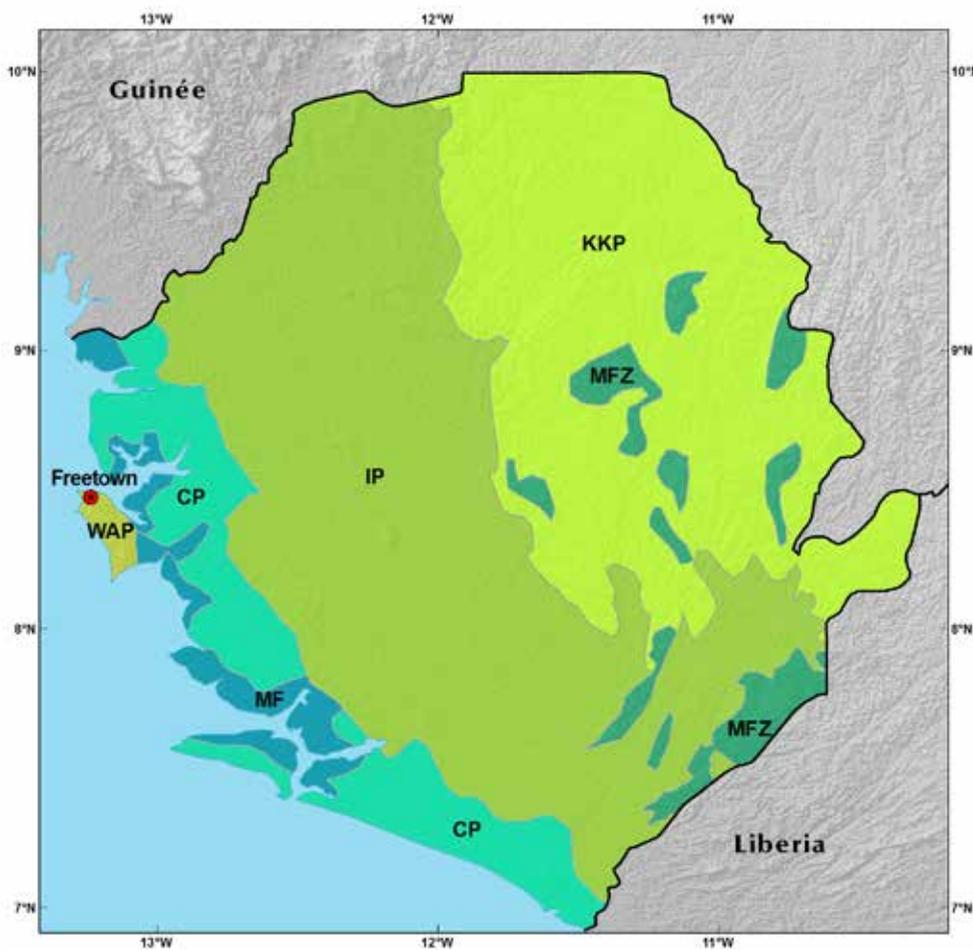
- National Park / Parc National
- Wildlife Sanctuary / Sanctuaire de Faune
- Forest Reserve / Forêt Classée
- National capital / Capitale nationale
- Other City / Autre Ville

Environmental Highlights:

- Deforestation
- Loss of biodiversity
- Wettest country in West Africa
- Substantial mineral resources
- High potential for ecotourism

Woodland in the Outamba-Kilimi National Park

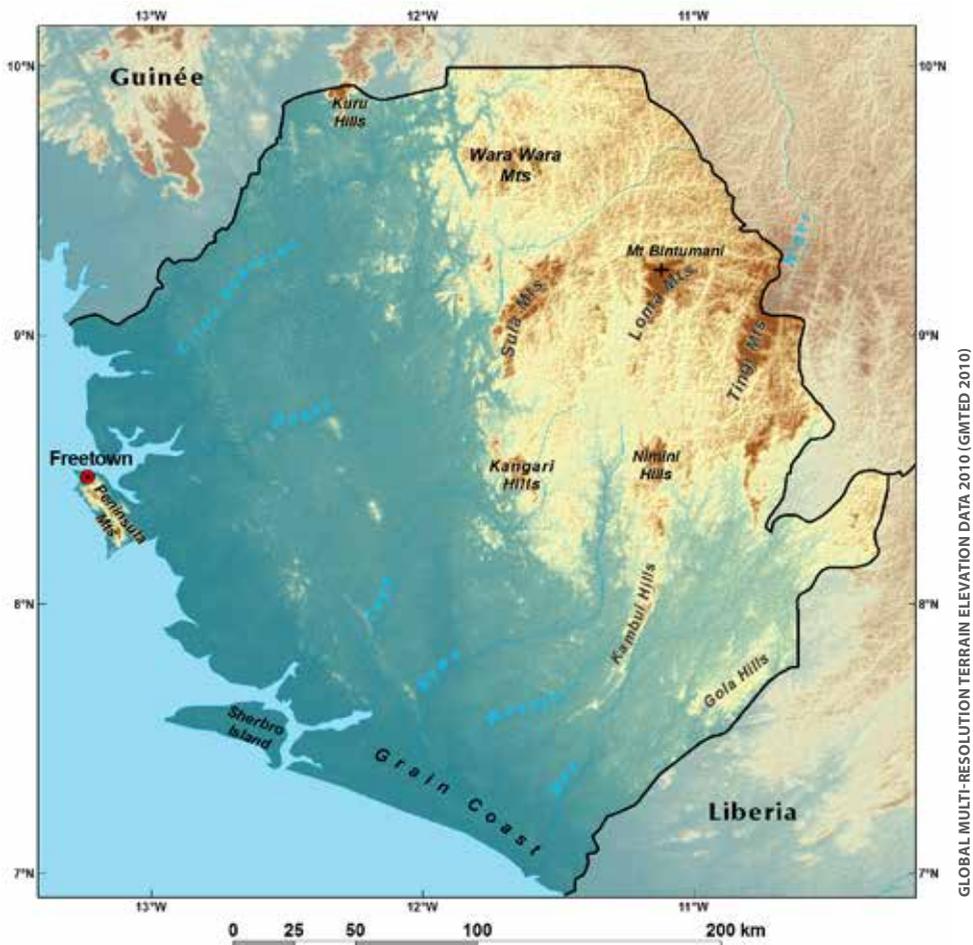
Ecoregions



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

Sierra Leone is divided into four main regions. In the east and the north, the Koinadugu and Kono Plateaus (KKP) ecoregion is an extension of the Guinea Highlands with several isolated mountains including the Tingi Hills, and the Loma Mountains where Mount Bintumani reaches 1,948 m. The plateau is mostly covered by a mosaic of woodland and savannas, interspersed with cropland. The high mountains of the Montane Forest Zone (MFZ) are dominated by tropical rain forests, often protected as forest reserve or national park. The northern part of the Koinadugu and Kono Plateaus (KKP) receives relatively less rainfall, often resulting in less dense and lower canopy height, even among mature stands of woodland (Munro and van der Horst, 2012). Parallel to the coastline, but inland of the coastal belt, are the Interior Plains (IP). This ecoregion of lowland plains, containing forest regrowth, woodland, savannas, and farmland, makes up about half of the country. Adjacent to the Atlantic shoreline are the Coastal Plains (CP) and the Mangrove Forest (MF) zones. The Gabro massif, confined to the Western Area Peninsula (WAP) where the capital city of Freetown is located, rises impressively from 200 m to 1,000 m above the low-lying narrow coastal area.

Shaded Relief



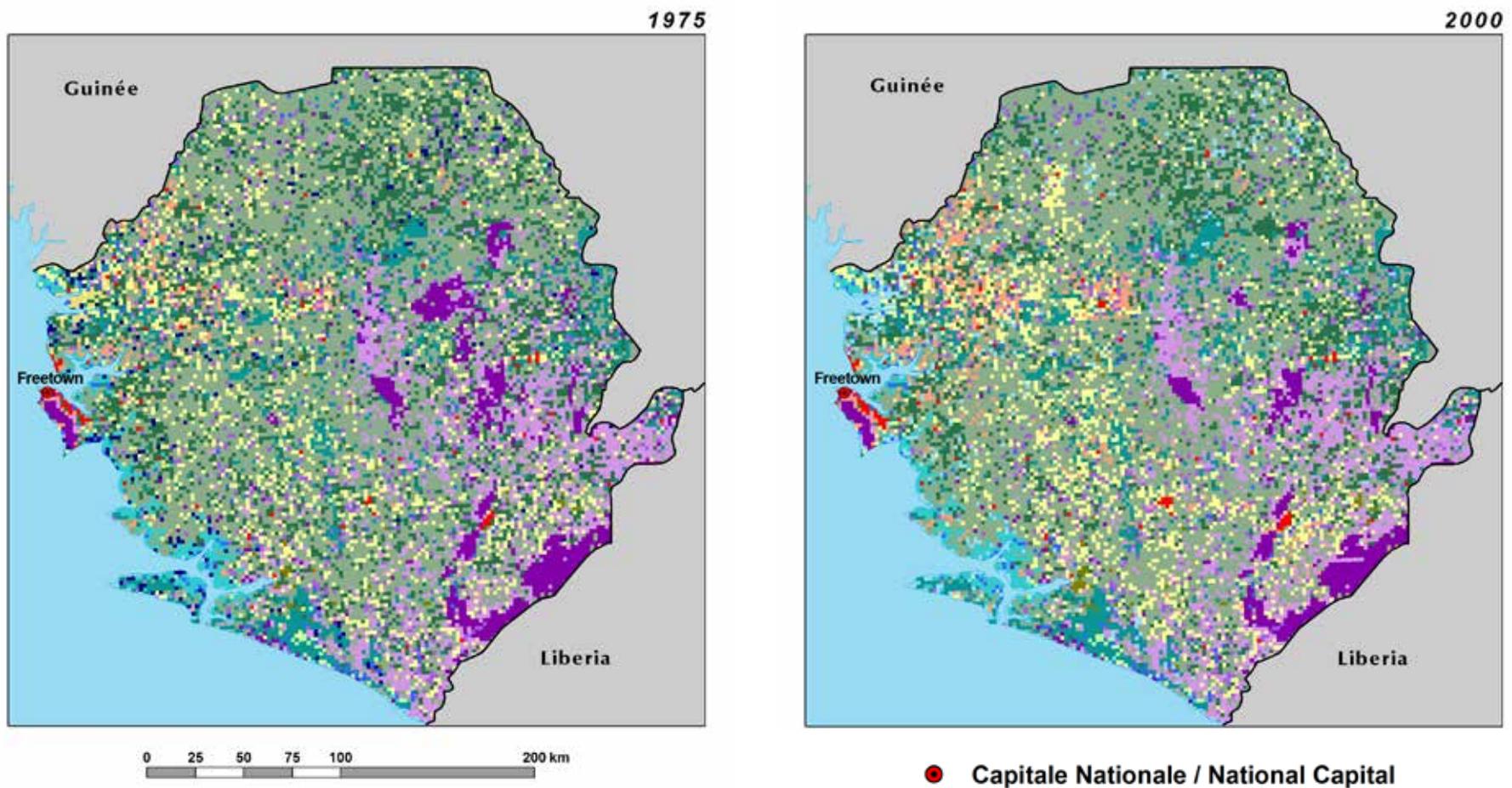
- High / Élevée
- Low / Faible



GRAY TAPPAN / USGS

Rapids on the Little Scarcies River, Outamba-Kilimi National Park

Land Use, Land Cover and Trends



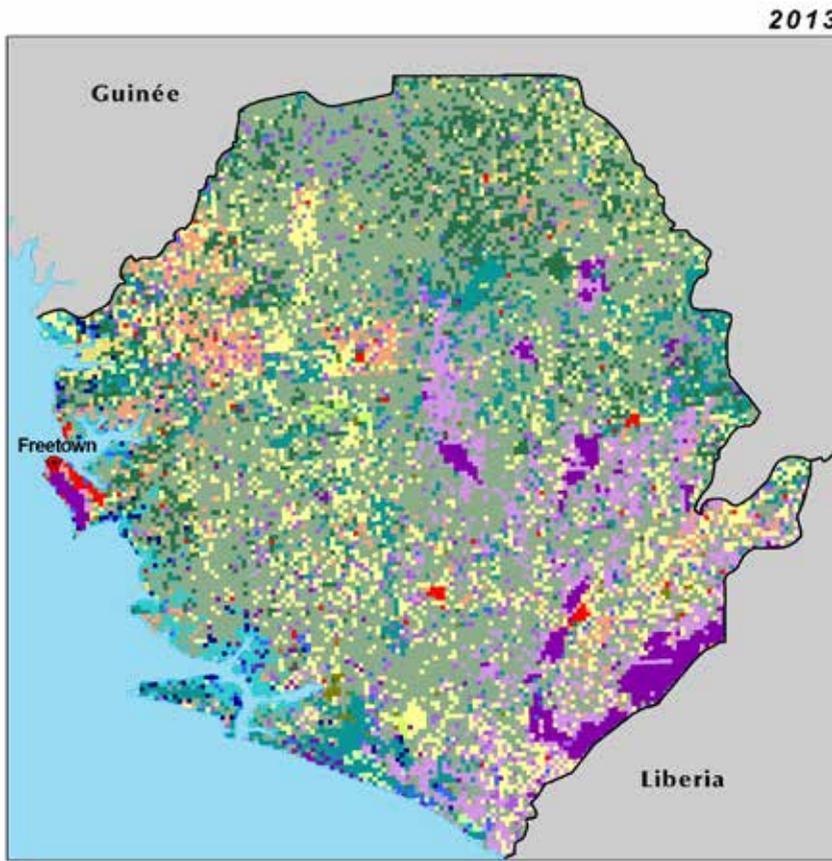
The most extensive land cover change in Sierra Leone was the loss of woodland and forested area across the country.

Dense forest is rare and mainly found on hill slopes in the Montane Forest Zone. Even though the country is located within the Upper Guinean forest ecosystem, it is unlikely that it was ever heavily covered by dense forest (Munro and van der Horst, 2012). Between 1975 and 2013, Sierra Leone lost 30 percent of its forest cover, or about 1,100 sq km, at an average annual rate of 0.8 percent. However, this rate has slowed since the end of the civil war, averaging 0.4 percent of annual forest loss between 2000 and 2013. The main loss of forest occurred in the Tama-Tonkolili and Nimini Hills highlands. In 1975, these tracts of dense forest were located among a patchwork of degraded forest, gallery forest, and woodland — none of which has been spared by deforestation. Degraded forest decreased

by 26 percent, or about 2,000 sq km, and gallery forest by 22 percent, or 700 sq km. Woodland is one of the dominant land cover types in Sierra Leone. It is found in the major ecoregions — on slopes and uplands of the Koinadugu and Kono Plateaus, and on the Interior and Coastal Plains, among the savannas and thickets. In 1975, woodland was the second largest land cover class in terms of area after the savannas, covering 15.5 percent of the country. Over the 38-year period, its area decreased by 48 percent, or 5,400 sq km, shrinking to a mere 8 percent of the country in 2013. Accounting for all the forest classes together, Sierra Leone lost a total 36 percent of its forest and woodland habitats since 1975.

Cropland expansion, slash-and-burn agriculture, logging, mining, and cattle grazing activities were the dominant factors affecting vegetation and land use. Indeed, resulting from an increasing demand for forest products and





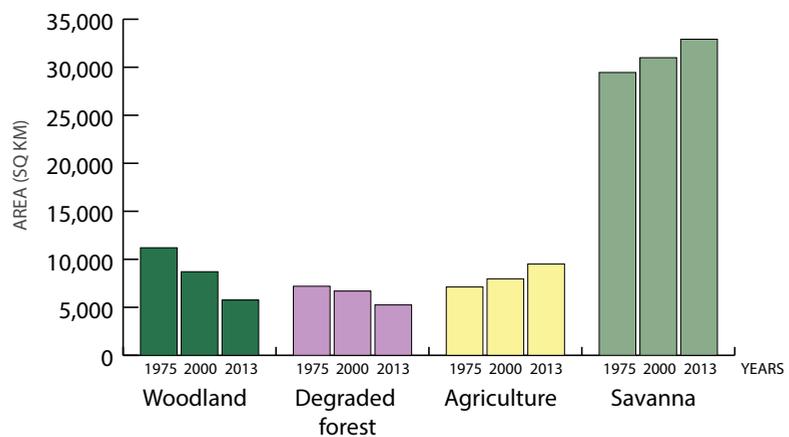
Land Cover / Occupation des Terres

- Forest / Forêt
- Gallery forest & riparian forest / Forêt galerie & formation ripicole
- Degraded forest / Forêt dégradée
- Woodland / Forêt claire
- Swamp forest / Forêt marécageuse
- Mangrove
- Savanna / Savane
- Herbaceous savanna / Savane herbacée
- Bowé
- Thicket / Fourré
- Agriculture / Zone de culture
- Irrigated agriculture / Cultures irriguées
- Agriculture in shallows and recession / Cultures des bas-fonds et de décrue
- Plantation
- Settlements / Habitation
- Bare soil / Sols dénudés
- Rocky land / Terrains rocheux
- Open mine / Carrière
- Water bodies / Plans d'eau
- Wetland - floodplain / Prairie marécageuse - vallée inondable

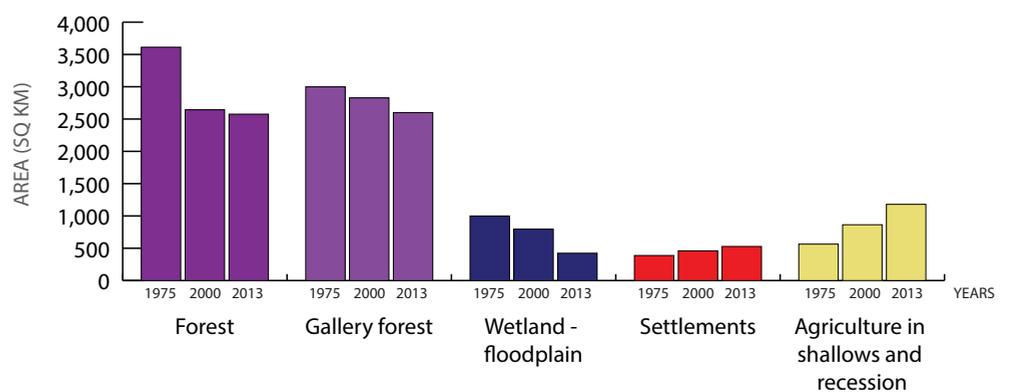
food production, half of the lost forest and woodland habitats were converted to savannas, and one-third to agriculture. Shifting agriculture has long been practiced in Sierra Leone. Under this system, a patch of forest is burned, cleared and cultivated usually for a short period of time (1–2 years), after which it is left fallow for several years. The rate of cropland expansion quadrupled after the end of the civil war, going from an average of 32 sq km per year in the 1975–2000 period to 130 sq km per year between 2000 and 2013. Overall, agricultural area progressed by 35 percent, or 2,400 sq km, between 1975 and 2013, mostly in the Interior Plains and in the northern part of the Koinadugu and Kono Plateaus. In Sierra Leone, where water is an abundant resource, bottomland and flood recessional agriculture is also very common. Many of the wetland areas mapped in 1975 have been converted to cultivated bottomland which has doubled in area, reaching 1,180 sq km by 2013.

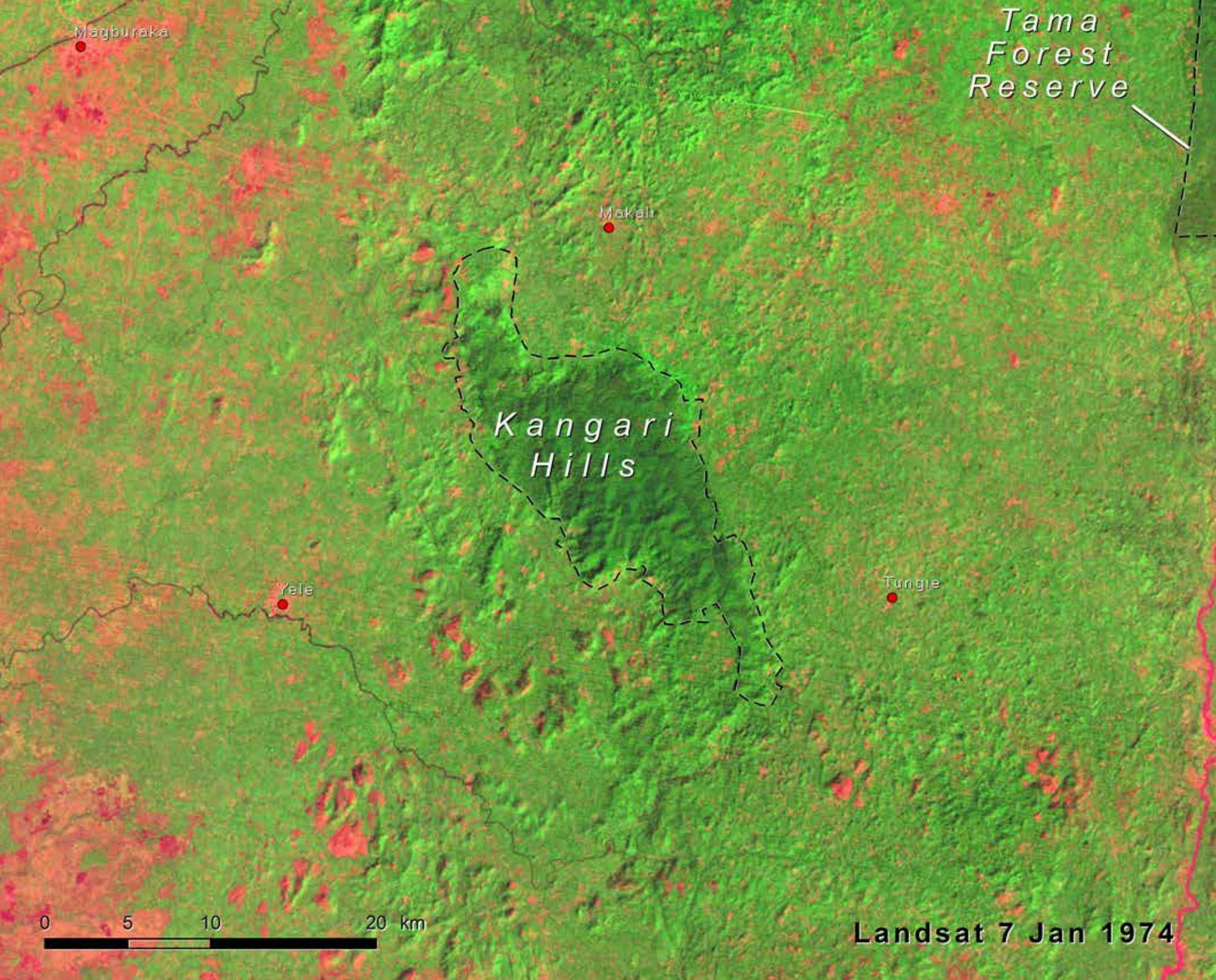
Because a large part of the population in Sierra Leone obtains its substance from farming, agriculture expansion was mostly driven by population growth. Whereas population increased steadily from 2.7 million to 6.1 million, a rise of 123 percent, the area occupied by settlements—towns and cities—only grew by 36 percent, or 140 sq km, from 1975 to 2013.

Large area classes



Small area classes

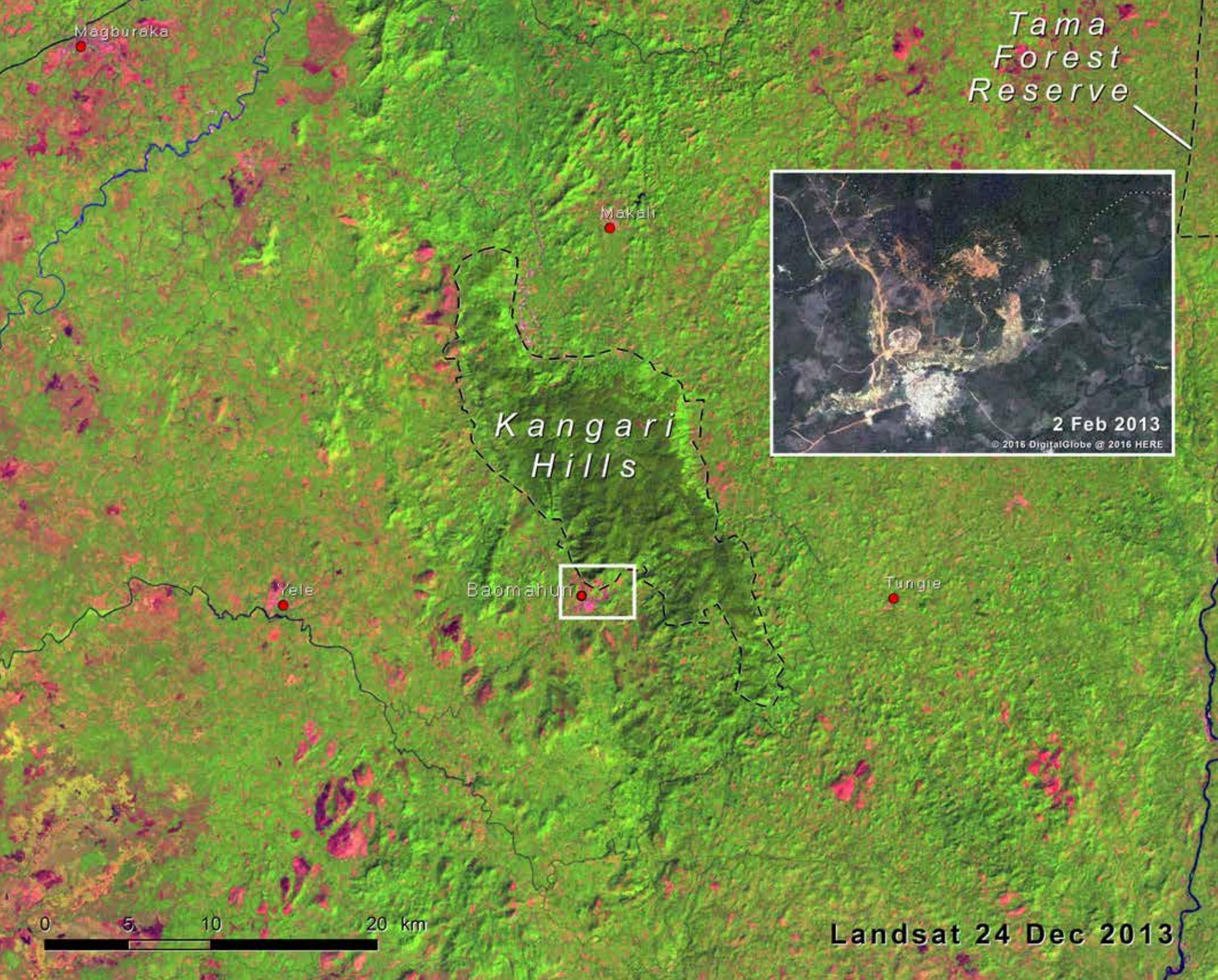




The Kangari Hills: A forest reserve with competing uses

Sierra Leone is endowed with two important natural assets, its mineral resources and its flora and fauna. Both can be found in the Kangari Hills. The Kangari Hills Forest Reserve covers 210 sq km and has been protected since 1924 as one of the few relics of the Upper Guinean forest ecosystem in the country. Key protected wildlife species include a remnant population of forest elephants, chimpanzees and other primates, as well as 115 documented bird species (Brcic and others, 2010). The forest is also used as a source of medicinal herbs and spices.

Landsat images from 1974 and 2013 evidence a remarkable stability of the extent of the forest in the Kangari Hills Forest Reserve. Forest stands out as the large dark green patch in the center of the images surrounded by a fine mosaic of farmland, savanna, and degraded forest. Some clearings are visible within the forest reserve as small brighter patches, but the extent of those has not significantly changed since the 1970s. Agricultural encroachment has taken place mostly from the north, where many villages are located. In contrast, the Tama Forest Reserve, located in the northeast of the images, had totally disappeared by 2013, entirely replaced by cropland and savanna. Logging roads also penetrate the southern part of the Kangari Hills Forest Reserve. The production and trade of charcoal has increased in the past decade and has become so lucrative that it has replaced farming. Unlike firewood, which is usually obtained from farms, wood for charcoal is harvested from forests and woodlands and often targets highly valuable hardwood species.



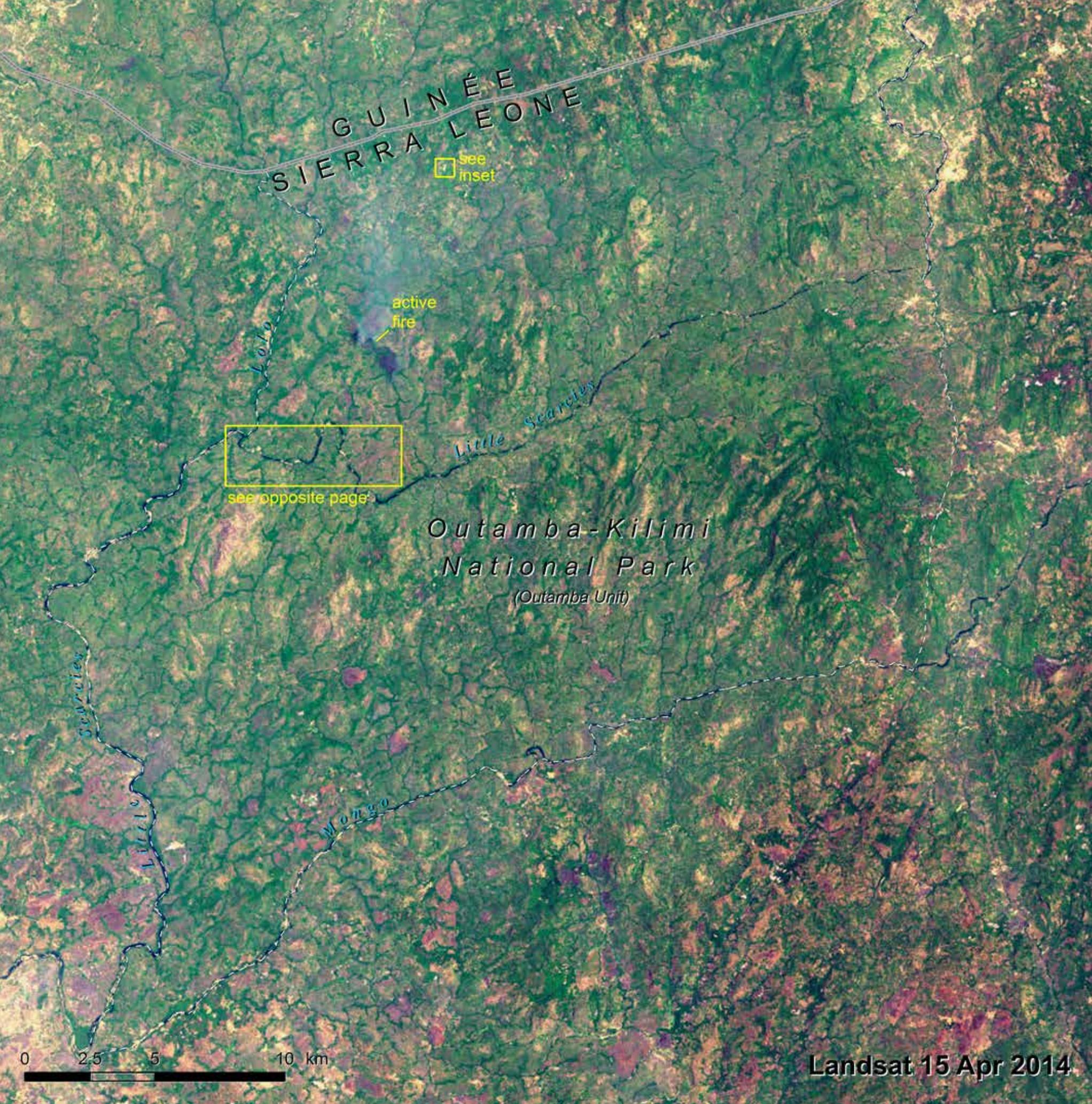
Illegal artisanal gold mining activities can be found throughout the Kangari Hills. With the British company Cluff Gold, the first industrial-scale gold mining operation began production in 2013 near the village of Baomahun, just to the southwest of the reserve (see inset). Cluff Gold claims to have found 3 million ounces of gold in and around the Kangari Hills. This value exceeds the entire Sierra Leonean economy by a factor of two, with the potential of tax revenues from the export of gold that can be invested into rebuilding the country's infrastructure (McClanahan, 2012). On the downside, the open pit mine leaves a huge scar on the land. Any form of deforestation diminishes forest resources, reduces wildlife habitat, and exposes the soil to erosion. With a mean annual rainfall of 3,500 mm, flash floods and landslides are common on denuded soil in this area.

With a relatively intact core of dense forest cover, the Kangari Hills Forest Reserve has an enormous potential for biodiversity conservation. Because of the carrying capacity and suitability of the habitat, it is being considered as a release site for rehabilitated captive chimpanzees. The massive demand for revenue from gold will undoubtedly put a lot of pressure on the reserve. The future of the reserve will depend on careful consideration of competing interests and striking a delicate balance between long-term restoration goals and income opportunities.



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Mining leaves forest degraded and vulnerable to soil erosion and landslides.



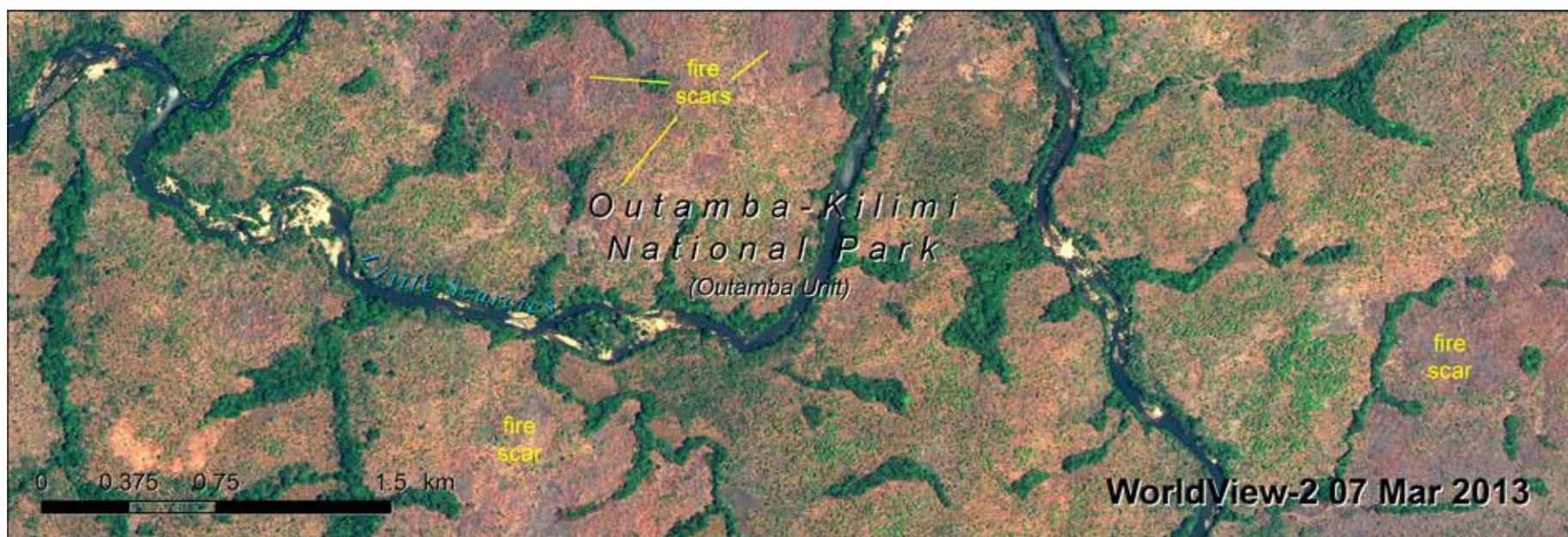
Landsat 15 Apr 2014



Outamba-Kilimi National Park

The Outamba-Kilimi National Park along Sierra Leone’s northwestern border with Guinea is made up of two separate units; Outamba to the east (shown above) and Kilimi to the west. Both are predominantly covered by woodland savanna with smaller areas of forest, gallery forest and open grassland. Outamba is generally more wooded than Kilimi and has more relief. Created in 1995 when hunting pressure was increasingly threatening the area’s wildlife, it was the country’s first national park.

Most of the park’s roughly 2,200 mm of rainfall falls from June to September followed by a dry season lasting from about November to April. Vegetation thrives during the rains and then much of it goes dormant during the dry season. This ready fuel makes fire a natural part of the Sudanian savanna landscape and it is fire that maintains



the boundaries between the grassy savanna and the denser forest areas which stay green year round (Trollope and Trollope, 2010; Hoffman and others, 2003). Fire scars and one still-burning fire can be seen in the Landsat image which was acquired as the 2014 dry season was ending (see image on the opposite page). The contrast between wet and dry seasons can be seen in the two high-resolution images. The top image (above) is from late in the dry season when savanna areas have gone dormant and fire scars are visible throughout the landscape; the image below is after the rains when all is green again and the next dry season is just beginning.

Human influence in Outamba-Kilimi is minimal with roughly 20 to 25 very small settlements (see adjacent inset) within the park (Brncic, 2010). While it is a national park and welcomes visitors, motor vehicles are restricted and visitors must explore the park on foot. The relatively pristine habitat of the park supports populations of several primates including the western chimpanzee, red colobus monkey, black and white colobus monkey, olive baboons, and the sooty mangabey (STEWART, 2012; Brncic, 2010). It is also home to a number of other large mammals including elephants, hippopotamuses, warthogs, red river hogs, leopards, African buffalo, bushbucks, bongo, duikers, gazelles and other antelope species (Brncic 2010). Bird species number over 250, including two which are of global conservation concern (Okoni-Williams and others, 2001).

The park's natural assets may provide potential for ecotourism development. Income from tourism could potentially provide the benefits to local communities that would help build trust and support for ongoing conservation efforts (Brncic, 2010). However, the park's remote location



and the memory of Sierra Leone's devastating civil war (1991-2002) has kept the number of visitors down.

Other potential threats to the park's integrity include poaching and mining. Occasional poaching of elephants is a problem according to Outamba-Kilimi's senior ranger, Dio Metzgehe. A group of poachers was arrested after several elephants were killed in 2009. Poachers also take smaller animals for bushmeat and fish illegally within the park. Artisanal mining in the streambeds within the park has also been reported (STEWART, 2012).