CASE STUDY

Coordinated and collaborative application of the mitigation hierarchy in complex multi-use landscapes in Africa: Gabon

Industry leadership and multi-stakeholder collaboration to mitigate impacts on high biodiversity values

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Report prepared by Fauna & Flora International

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SYNOPSIS

- The case study is structured around **a conceptual framework** aimed at embedding **nature and socioecological considerations into land use and development processes** and **encouraging coordinated and collaborative application of the mitigation hierarchy at company operation and landscape scales**. Themes of relevance are explored in the context of a landscape in south-west Gabon.
- **Practical examples of industry leadership,** application of **industry best practice mitigation for biodiversity and ecosystem services** and **multi-stakeholder collaboration to achieve project and landscape aims** are provided**.** The role of industry and government is highlighted.
- The case study focuses on a **multi-use landscape with high biodiversity and conservation values.** The landscape supports a mosaic of habitats, including forest-savannah, fresh-water swamps and coastal forest. The forests are part of the world's second largest contiguous block of tropical rainforest. The landscape is characterised by high diversity and endemism, and is home to threatened iconic species, including western lowland gorilla, central chimpanzee and African forest elephant. Two of Gabon's 13 national parks are within the landscape.
- **The operations of multiple sectors (oil & gas, forestry and palm oil) in the landscape provide both threats and positive contributions to conserving social and ecological values**. The onshore oil & gas sector, which has dominated activities in the landscape for over 60 years, is in decline. It is no-longer cost-effective for larger companies to exploit diminishing reserves. There is a risk that these companies will be replaced by smaller companies which may not be bound to respect environmental and social measures in terms of reputational risk, financing regulations or other drivers of industry good practice.
- **Indirect and cumulative industry impacts alongside unregulated development pressures threaten the persistence of social and ecological values in the landscape**, including from the growth of Gamba Town, unplanned conversion to subsistence agriculture, human-elephant conflict and a high prevalence of poaching of small and large game.
- **Direct, indirect and cumulative industry impacts are explored in the context of species-specific responses to industry impacts** due to the species social and biological requirements.
- **Strong national policies for sustainable development provide a supportive framework for environment, industry and society within the Landscape.** Proposed national landscape level planning, alongside enforcement and monitoring of legislation will help ensure ecological and social values persist. Providing an enabling environment for industry leadership, and where leadership or industry commitment is lacking, the regulatory requirement for companies to implement good practice impact mitigation. Especially important during this period of dynamic change.

CONTENTS

INTRODUCTION

Focusing on a landscape in south-west Gabon, Central Africa, this case study explores themes of relevance to a conceptual framework developed for use in complex multi-use landscapes by Fauna & Flora International (FFI). The framework (shown in Figure 1) aims to embed nature and socioecological considerations into land use and development processes and to encourage coordinated and collaborative application of the mitigation hierarchy at company operation and landscape scales (see report produced by FFI, 2021a).

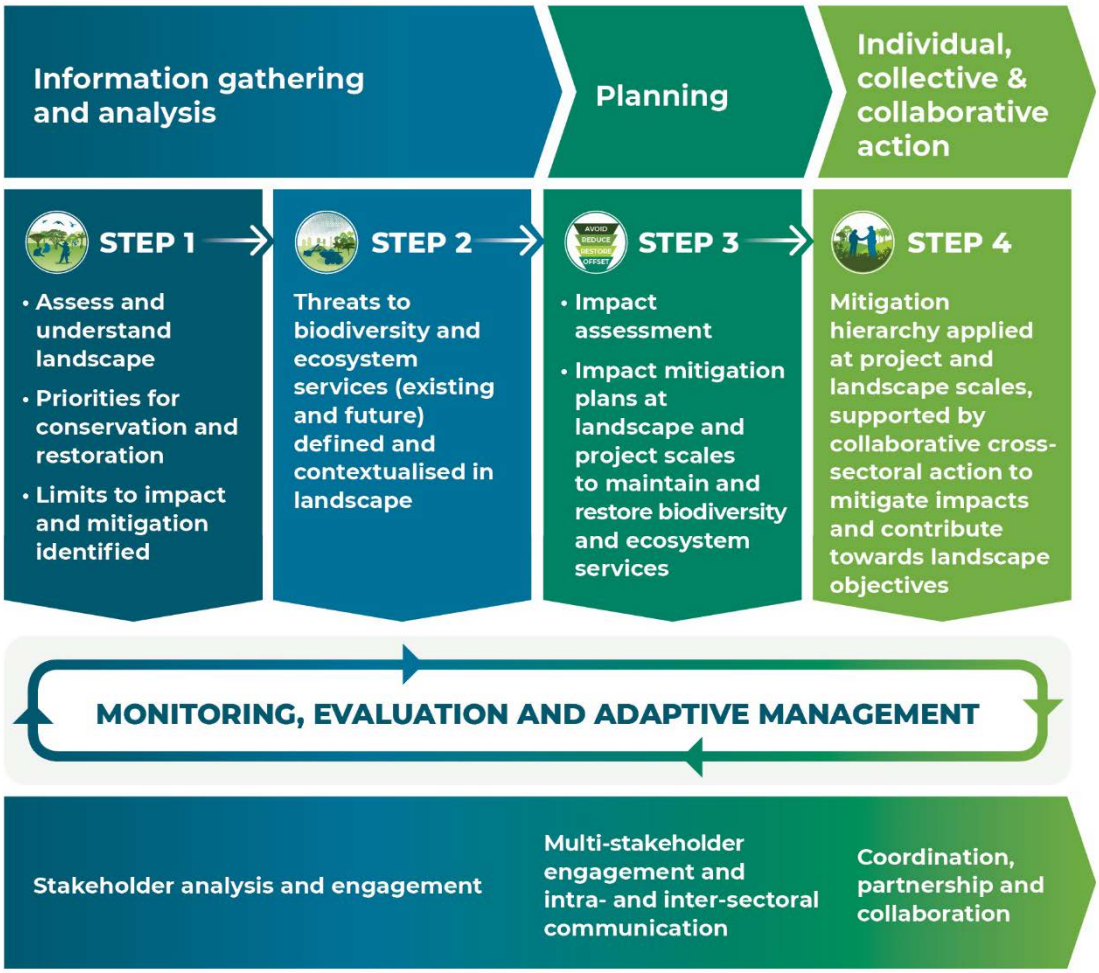

Figure 1 Main steps of the conceptual framework

The Focal Landscape has been selected because it is an example where the actions of leading individual companies, and a number of collaborative initiatives, have aimed at the coexistence of industrial development, including oil & gas, forestry and agriculture, alongside the persistence of high biodiversity values which are characterised by a vast wilderness harbouring iconic endangered large mammals. Activities within the landscape are in line with the aims of the conceptual framework, and as such, provide relevant practical experience and inspiration to others who may wish to apply the framework, particularly Steps 3 and 4, within their own landscapes.

Drawing on available literature, this desk-based case study firstly presents high-level overviews of the important social and ecological values within the landscape and an

indication of the pressures and threats to these values from industry and unregulated activities. This provides context for the case study, as well as providing preliminary background information on themes relevant to Steps 1 and 2. For the purpose of this case study, we focus on three umbrella species of conservation concern, the western lowland gorilla, central chimpanzee and African forest elephant and consider their respective ecological requirements. Together these species are important indicators of ecological integrity, their protection benefits other sympatric species, and they share traits similar to duikers, sitatungas and hogs (such as food niche, forest dependence, home range size and sensitivity to disturbance), are of conservation concern and particularly sensitive to population loss due to low reproductive rates (Vanthomme et al., 2019). The case study looks in more detail at the species-specific responses to impacts and to mitigation actions which are important to consider during Step 3 when understanding impacts and setting appropriate mitigation actions. Finally, it highlights the role of industry in multi-partner collaborative action to achieve landscape objectives, which is a key theme in Step 4.

The case study does not attempt to provide a systematic or in depth application of the framework, which would require further research, ground-truthing and require an in-country stakeholder engagement process.

THE FOCAL LANDSCAPE

Figure 2 Map of Focal Landscape and Gabon (yellow outline marks the Gamba Complex, white lines show county borders)

Situated in the southwest of Gabon, the Gamba Complex of Protected Areas (GCPA) is central to the Focal Landscape (Figure 2). The GCPA includes two national parks with a high conservation value 'industrial corridor' between the parks where oil extraction and timber harvesting occur. Oil extraction has occurred here since the 1960s and selective logging since the early 1920s (Alonso et al., 2014a). For the purpose of this case study, the Focal Landscape extends beyond the GCPA towards Mouila to include oil palm plantations, north to Omboué where oil extraction is taking place and south towards Mayumba where logging occurs. The GCPA and this wider area intersects partially with a larger recognised transboundary ecological landscape unit defined by the Congo Basin Forest Partnership - the Gamba-Mayumba-Conkouati Landscape; this is likely one of the most diverse landscapes in Central Africa (The Congo Basin Forest Partnership, 2006).

ESTABLISHING THE LANDSCAPE CONTEXT – SOCIAL AND ECOLOGICAL VALUES

STEP 1
Assessing and understanding the landscape, identifying conservation and restoration priorities, and setting limits

STEP 1 | STEP 2 | STEP 3 | STEP 4

Central to Step 1 is gathering and analysing information in order to understand the socio-economic and policy/ legal context, biodiversity and ecosystem service uses and values, the ecological requirements that need to be maintained for those values to persist, identifying priorities for conservation and restoration and if there should be limits set on what can be impacted for development purposes.

This section focuses on a brief summary of landscape governance and socio-economic context, largely based on what is happening at the national level, current biodiversity and ecosystem service values and uses are presented and biodiversity commitments.

Landscape governance and socio-economic context

Gabon is one of only a few **upper-middle-income countries** in Sub-Saharan Africa. It has **rich and diverse natural resources** including petroleum, manganese, uranium, iron ore, diamonds and gold, extensive forests, as well as fertile lands and fisheries. Gabon has an estimated population of 2.1 million and is **one of the least densely populated countries in the world** at 8.4 inhabitants/ km^2. However, the population is young and growth rates are high, with an average annual population growth rate of 3.6%. The human population and economic activity are concentrated in urban centres, with 60% of the country's economic activity and 59% of the population centred in the two main cities of the capital Libreville and Port-Gentil.

The **oil boom** of the 1960s to 1990's has dominated Gabon's development trajectory bringing improvements in GDP and living conditions. However, the institutional

foundations to sustain the gains were not put in place and early social and economic achievements were lost as commodity prices fell. Unemployment rose after the collapse of oil prices in the mid-1980s and currently **unemployment is amongst the highest in Africa** at 19% of the labour force. As oil revenues fell, so too did public sector job opportunities which were once seen as a secure career for life by secondary school level educated youth, who now account for 60% of the unemployed (World Bank Group, 2020a).

The oil industry prompted a **migration from rural to urban areas** resulting in most Gabonese (90% in 2019) living in a handful of cities. Informal settlements and poor living conditions prevail in towns due to poor urban planning and the misuse and misappropriation of local taxes. Public services in rural areas are costly or lacking, resulting in a reliance on ecosystem services for basic needs (United Nations, 2020; World Bank Group, 2020a).

Currently, Gabon achieves relatively **low scores on the 2019 Human Development Index (115 out of 189) and on the Sustainable Development Index (111 out of 193 countries).** For the latter, significant and major challenges remain to meet all 17 of the Sustainable Development Goals (SDG), though notable progress is being made towards life on land (SDG 15), climate action (SDG 13) and affordable and clean energy (SDG7) (United Nations Development Programme, 2019; Sachs et al., 2020; World Bank Group, 2020a). For example, new legislation is in place or planned, including a new law on Sustainable Development (No. 002/2014), updates to the Forest Code of 2001 (currently in draft), a new regulatory framework to control bushmeat hunting and marketing as well as strengthening the criminal framework against wildlife and ivory trade (République Gabonaise, 2015; Central African Forest Initiative, 2020a, 2020b).

The Focal Landscape is representative of wider national trends and linked to the rise and fall of the oil industry. Within the Focal Landscape, Mouila, Tchibanga, and Gamba Town are the larger urban centres. Prior to the oil boom the Gamba Complex was characterised by a network of small hunting, farming and fishing communities around the Ndougou Lagoon (WWF, 2020a). Gamba town, the main town in the Complex, grew from a small fishing village to a current population of 8,500-16,000 as a result of in-migration for the oil industry and support services and represented the majority of the working population in the town. It expanded rapidly in the 1960's after the discovery of the Gamba 1 oil field, and again in the 1980's after the discovery of the Rabi-Kounga field and declining since the peak of production in the 1990's (Alonso et al., 2014b).

As with the national trends, unemployment has risen around the GCPA since Shell left in 2017 and there is still a push towards urban migration from rural agriculture based livelihoods (Van Gils et al., 2019).

As **oil reserves decline and development challenges grow in Gabon**, the Government has set out an ambitious **'Emerging Gabon Strategic Plan to 2025'** to accelerate economic growth and economic diversification, reduce poverty and inequality and to sustainably manage the country's resources (République Gabonaise, 2012). The plan is based around three pillars, Industrial Gabon, Service Gabon and Green Gabon. The first two pillars focus on developing the mining, fertiliser and electricity sectors and the growth of human capital to build a digital economy and become a regional service provider. Green Gabon is aimed at environmental preservation and restoration, sustainable development of agriculture, forestry and fisheries (République Gabonaise, 2015).

The **governance and capacity building frameworks to support the plan are being put in place**. In partnership, Central African Forest Initiative (CAFI) and the Government of Gabon have agreed a National Investment Framework to facilitate Gabon's sustainable development, climate and conservation goals. Under the Framework, CAFI is providing funding (2018-2022) for the development of a National Land Use Plan to clarify land use rights and to guide expansion of the land based industries and infrastructure central to the Emerging Gabon Strategic Plan to 2025 in order to mitigate impacts on forests. However, progress on implementation of the National Land Use Plan is slow. Within the Focal Landscape there is currently no government land use plan, however, decades of research to build biodiversity knowledge, multi-partner landscape-level zoning, protected area and other management plans developed for the Gamba Complex will support and be supported by the National Land Use plan when it happens (The Congo Basin Forest Partnership, 2006; Compagnie des Bois du Gabon, 2020). Funding has also been provided to establish a monitoring system for natural resources to detect real-time deforestation events. The United Nations Development Programme is funding a programme to intensify crop production to improve food security without expanding into forests, and increasing the capacity of the Agricultural Minister to reform agriculture and take part in the national land use planning process.

Indicative of the government's ambitions for climate, biodiversity and sustainability, in addition to the strong sustainable development focus of the national strategic plan the government of Gabon has made a number of **sustainability commitments under various international and regional agreements**. Internationally, this includes membership and signatory to the Convention on International Trade in Endangered species of wild fauna and flora (CITES), United Nations Convention on Biological Diversity, UN Framework Convention on Climate Change (UNFCCC), UN Educational, Scientific and Cultural Organisation(UNESCO) World Heritage Convention, UN Collaborative Programme on Reducing Emissions from Deforestation and forest Degradation (UN-REDD+), UN Agenda 2030 and the SDGs, the Ramsar Convention on Wetlands of International Importance, and the International Tropical Timber Organisation (ITTO). Regionally, this includes membership and participation in CAFI and African Union's Agenda 2063 amongst others.

The policy framework is in general supportive of a sustainable development trajectory which can enable maintaining its forest-biodiversity related values.

Biodiversity and ecosystem services values and uses

Biodiversity values and uses

Central Africa houses the world's second largest contiguous block of tropical rainforest. With over 85% of Gabon covered by moist tropical forest it is an important part of the forest block. Gabon's flora is classified in the Guineo-Congolian **regional centre of endemism** and has among the **richest lowland diversity** in Africa.

The GCPA represents the range of species and habitats found within Gabon, it is the largest and likely **most diverse protected area** in Gabon (11,320 km^2). It represents three land ecoregions: the northwest Congolian lowland forests, western forest-savannah mosaic, and the Atlantic equatorial coastal forests. As such, it supports a mosaic of habitat types including 'coastal beaches, dunes, mangrove forests, littoral forests, coastal scrub,

freshwater and brackish swamps, lowland and permanently-inundated forest, upland forest, rocky outcrops, various stages of secondary forest, prairie, papyrus and *Raphia* marshes, and extensive freshwater and brackish wetlands' (Lee et al., 2006; The Congo Basin Forest Partnership, 2006).

There are **11 protected areas** across the landscape, ten of these are together called the Gamba Complex of Protected Areas (see Figure 3). It includes two of Gabon's 13 National Parks (Loango and Moukalaba-Doudou National Parks) flanking contiguous hunting (Iguéla and Ngové-Ndogo both IUCN category IV, Setté Cama – a Ramsar Site and Moukalaba) and faunal reserves (Plaine Ouanga, Petit Loango – a Ramsar Site and Moukalaba-Dougoua, the latter IUCN category IV) and one Wildlife Management Area (Monts Doudou) (UNEP-WCMC, 2020). To the north, the Focal Landscape also marginally overlaps the edge of Bas Ogooué a Ramsar Site, wetland of international importance.

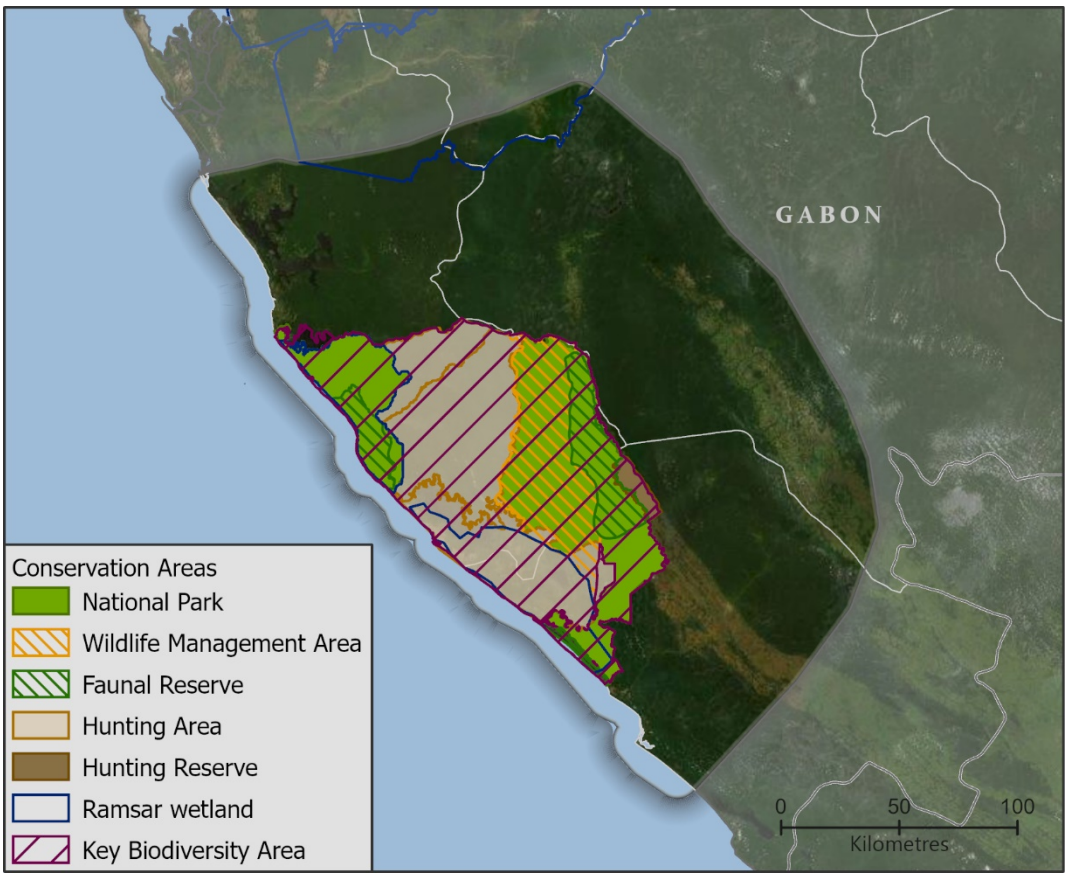

Figure 3 Map of protected areas (Loanga National Park is to the left, Moukalaba-Doudou is to the right)

The whole of the GCPA is recognised as a **Key Biodiversity Area** (KBA) based on its 2001 Important Bird and Biodiversity Area assessment, requiring assessment against the global KBA standard (Key Biodiversity Areas Partnership, 2020). Additionally Moukalaba-Doudou National Park has been listed on the UNESCO World Heritage Site tentative list since 2005 in recognition of the presence of ancestral sacred sites, floral endemism, migratory birds, its role as a wildlife refuge, and the evolutionary processes associated with ecotones according to transitions in altitude and habitat (UNESCO, 2020).

Within the Focal Landscape, **high value habitat** is found both within and outside the GCPA. As with the rest of Gabon, the Focal Landscape has extensive forest, covering over 90% of the area, with the majority of the forest areas (>95%) having canopy cover of 75-

100% and over half the area with tree heights over 15 m (Figure 4, 5, 6). The most extensive core habitat[1] is found within the Moukalaba National Park (Figure 5, Figure 7). Approximately 48.5% of extant forest area within the Focal Landscape is forest edge habitat[2]. Forest edges can be associated with the decline of biodiversity and ecosystem function worldwide e.g. through species sensitivity to changes in the microclimate (Pfeifer et al., 2018). However, within the Focal Landscape, forest-savannah mosaic and wetlands are the natural habitat and therefore forest edge ecotone is largely an inherent feature of the natural state.

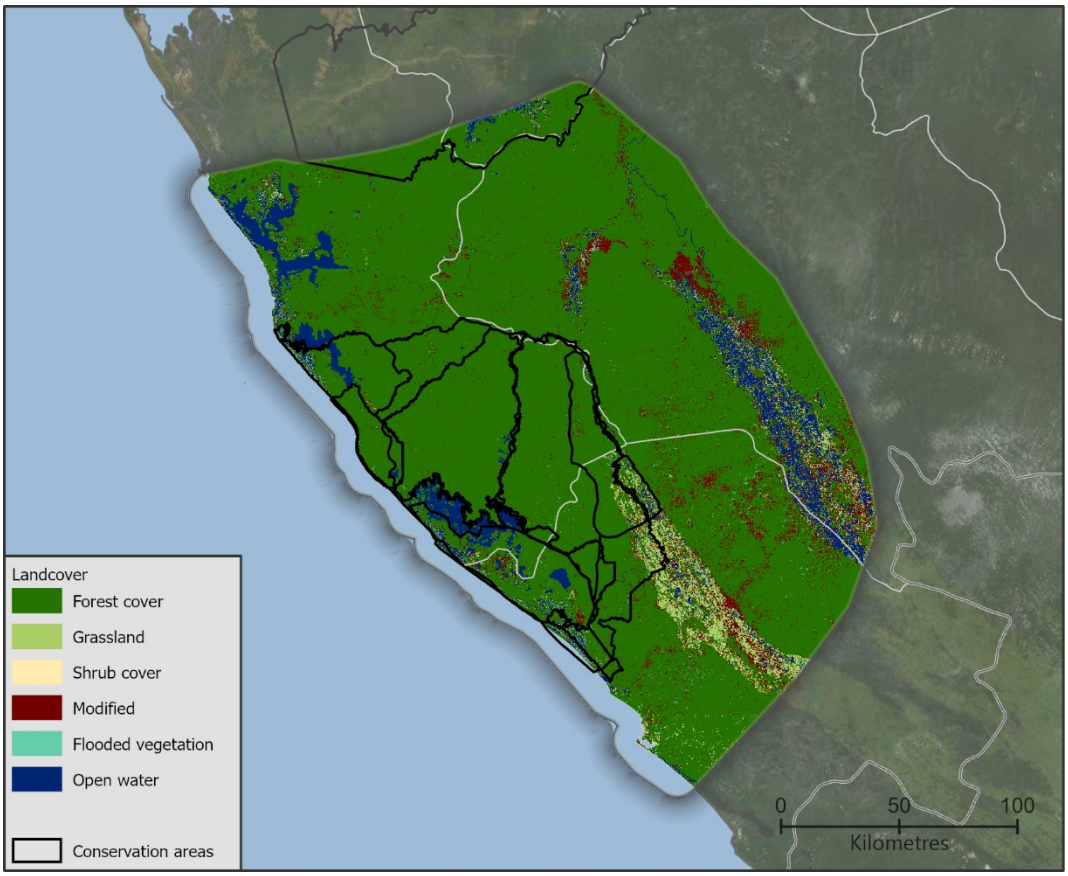

Figure 4 Habitat map

[1] Habitat that is contiguous and is the interior area of an extant forest patch. For the purpose of application in this case study, core habitat represents the extant forest habitat that has not been exposed to threatening pressures and therefore could be considered primary forest habitat of pristine condition which is representative of the forest ecosystem type.
[2] Habitat that is at the perimeter of extant forest patches and is exposed to non-habitat classes. In this case study, the edge boundary was set at 200m which represents the absolute limits of threats and exposure from non-habitat areas that habitat within a forest patch might be subjected to. The edge class consists of all the exposed forest habitat classes within this buffer distance, in addition to any connecting bridge habitat between forest patches that is less than the buffer distance or any perforations or incursions within core habitat areas. For the purpose of application in this case study, edge habitat represents forest habitat that has been degraded due to threats and pressures emanating from non-habitat areas and any ecotone or transition forest habitat that may not be representative of its associated forest ecosystem type.

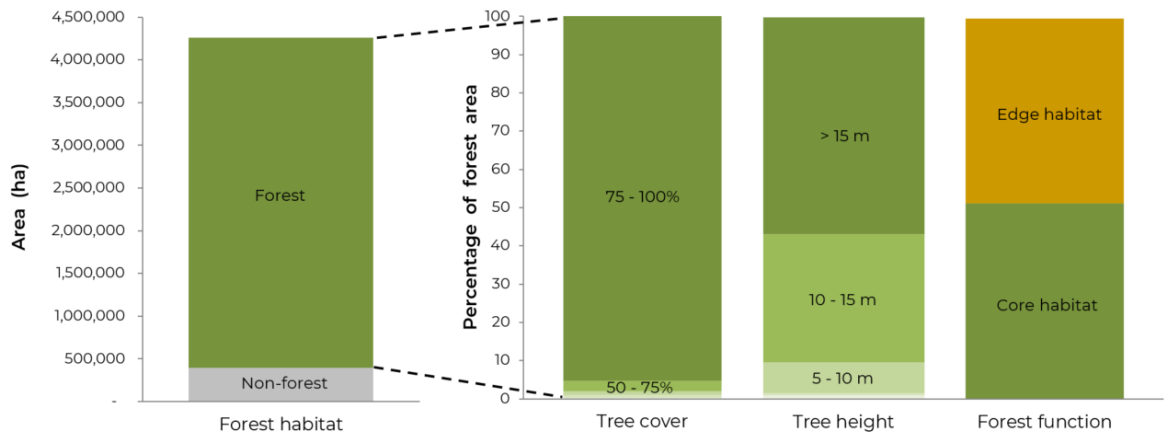

Figure 5 Graph showing forest habitat, tree cover, tree height and forest function

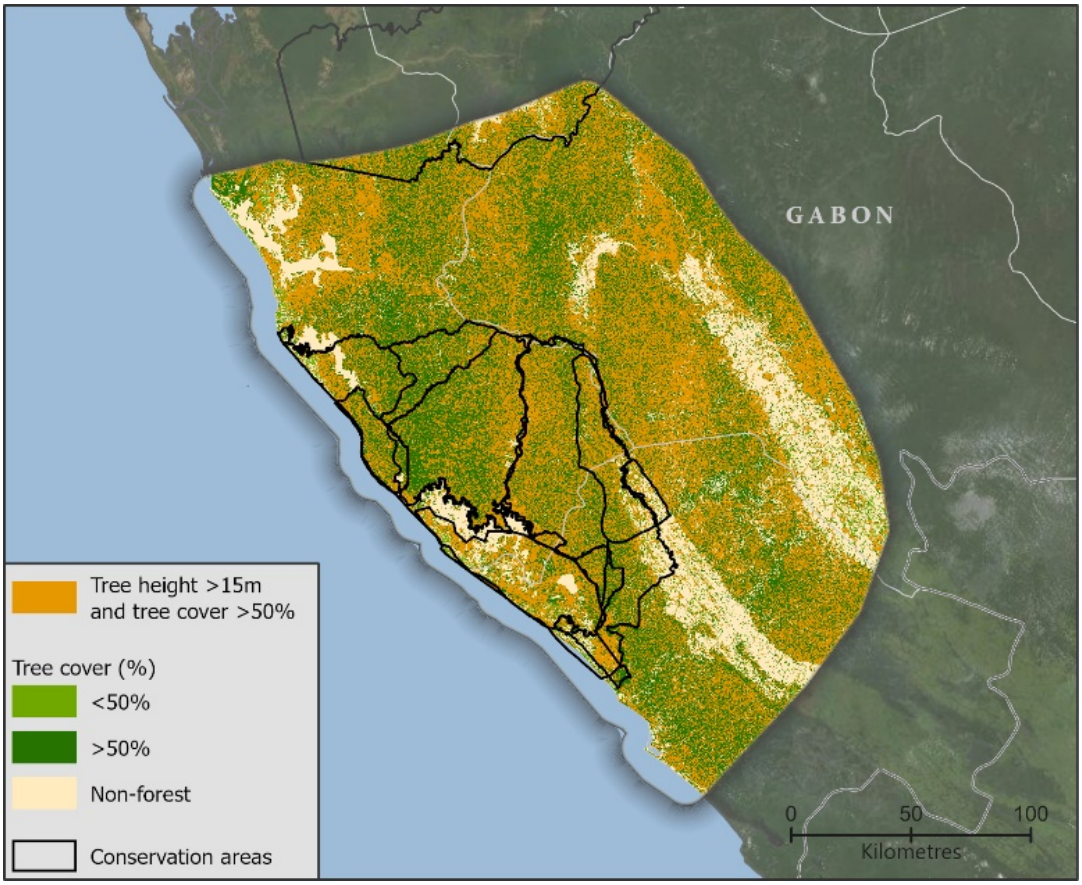

Figure 6 Extant forest cover at a minimum 50% tree cover, with tallest tree height ≥15 m indicative of important habitat (orange)

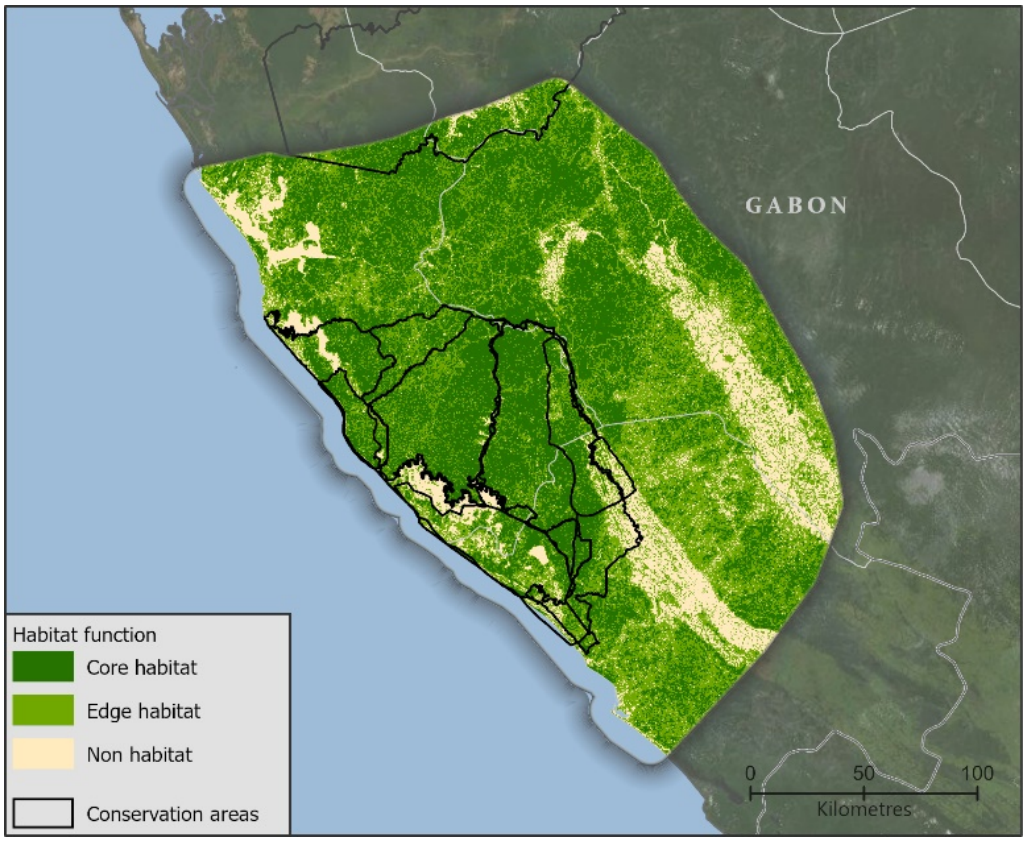

Figure 7 Extant forest cover with core habitat (dark green) and exposed edge habitat (light green)

The Focal Landscape supports important **populations of globally threatened and iconic species.** Based on the IUCN Red List database, this includes at least the following terrestrial species:

- Three Critically Endangered (western lowland gorilla (*Gorilla gorilla gorilla*), the freshwater Slender-snouted crocodile (*Mecistops cataphractus*) and nesting beaches for the Hawksbill turtle (*Eretmochelys imbricate*)
- 12 Endangered (e.g. central chimpanzee (*Pan troglodytes troglodytes*), Red-capped mangabey (*Cercocebus torquatus*), grey parrot (*Psittacus erithacus*), giant ground pangolin (*Smutsia gigantean*))
- 37 Vulnerable (e.g. African forest elephant (*Loxodonta africana*), hippopotamus (*Hippopotamus amphibious*), leopard (*Panthera pardus*), African manatee (*Trichechus senegalensis*) found in the lagoons and rivers, and nesting beaches for turtles including the leatherback (*Dermochelys coriacea*).

The Focal Landscape is recognised by IUCN as **one of ten important priority landscapes for the conservation of the central chimpanzee and western lowland gorilla**, supporting significant numbers at healthy densities (IUCN, 2014). Across their range, the largest gorilla and chimpanzee populations are resident in Gabon and Congo. Gabon harbours 27% of the entire gorilla population and 34% of the chimpanzee population.

Gorillas and chimpanzees are found in intact and hinterland[3] forest with a preference for medium (25-35 m) or high (>35 m) canopy (Strindberg, 2018). Swamp forests are also important habitats for lowland gorilla and in Congo are found to harbour high densities compared to other forest types, although chimpanzee densities tend to remain low (Poulsen & Clark, 2004; Rainey et al., 2010). The Focal Landscape has suitable habitat for both species both within and outside the protected areas. Parts of the Moukalaba-Doudou National Park are amongst the highest densities in their range for gorillas (pers. comms. A. Todd 2020). Chimpanzees are found wherever forest remains, even if selectively logged historically and modelling by Strindberg suggests they may be relatively abundant in unprotected coastal forests towards Mayumba Town, in the southeast of the Landscape (Strindberg et al., 2018). Strindberg's study highlights that, across their Central African range, over three-quarters of gorillas and chimpanzees may live outside of protected areas and an estimated 58.7% of gorillas and 65.8% of chimpanzees live in habitat that is unprotected by rangers. Across their range, both species are declining, **threatened primarily by poaching, habitat degradation and disease** (Strindberg, 2018).

The GCPA is a **global stronghold for African forest elephants** and holds some of Gabon's most significant populations of African forest elephant (3,033-6,043 individuals based on abundance estimates) (Lee et al., 2006; Johnson et al., 2019; Brand et al., 2020). Populations of this large-ranging mammal are **declining due to habitat loss, fragmentation, poaching (for ivory),** and the species is increasingly a source of **human-wildlife conflict** within the Focal Landscape. Research efforts are underway to fill knowledge gaps relating to the social behaviour and population dynamics of the elephants in relation to increasing threats in order to define appropriate management as well as providing a useful ecological indicator of connectivity within the landscape (Dallmeier et al., 2006; Johnson et al., 2019; Brand et al., 2020).

The Landscape is also important for certain **large mammals of IUCN red-list Least Concern**, including the Marshbuck (*Tragelaphus spekei*) and the last important population of Waterbuck (*Kobus ellipsiprymnus*) in Gabon (Birdlife International, 2020) .

The landscape supports areas of **high endemism**. This is particularly associated with medium and high altitudes for example Monts Doudou mountain range within Moukalaba-Doudou National Park (800m in altitude), has more than 1,000 vascular species, of which 50 are strict endemics (WWF, 2020b).

Ecosystem services values and uses

The Landscape's forests and other natural and agro-ecosystems provide **essential ecosystem services for a range of beneficiaries from local to global scales**. These are summarised at a high-level in Table 1 and include carbon sequestration and storage, watershed protection, coastal protection, and provisioning services with subsistence, income generating and cultural values.

[3] Hinterland forest is defined as forest patches absent of and removed from disturbance in the near term history, taller than 5 m and with a canopy cover equal to or above 25%) (University of Maryland, 2020)

Table 1 Ecosystem services and beneficiaries relevant to the Focal Landscape (note these are not based on stakeholder engagement)

TYPE OF ECOSYSTEM SERVICE	ECOSYSTEM SERVICE DESCRIPTION AND SOURCE	BENEFICIARIES
Provisioning services	• Wild fauna (bushmeat, turtle eggs) from forests, savannah and coast for food, medicine and trade (subsistence use and commercial, often illegally).	• For bushmeat, local communities (rural and urban), national, international.
	• Wild forest flora for food and medicine include most commonly *Dacryodes buettneri*, fungus (*Termitomyces spp.*) and Gabon nut (*Coula edulis*) for subsistence. Bush Mango (Irvingia gabonensis) for subsistence with surplus for sale. Contribution to food and income from forest plant sources is small.	• For flora, local communities.
	• Timber extracted for international trade, local construction and firewood.	• Local communities and national economies.
	• Freshwater fisheries in lagoons and rivers for protein and income from trade. Marine fisheries for protein and income at Mayumba.	• Local communities (coastal, lagoon villages, Mayumba and Gamba Towns).
	• Water (surface and ground) for domestic use.	• Local communities.
Regulating services	• Climate change mitigation through carbon storage and sequestration provided by the landscape's forests.	• All humankind.
	• Sediment retention and soil erosion prevention provided by forest and other vegetation cover maintaining water quality.	• Local communities.
	• Maintenance of soil fertility provided by forest cover.	• Local communities.
	• Watershed protection. Forests provide catchment protection, driving the water cycle, regulating water flows, protecting water quality, and maintaining aquatic habitats.	• Local communities and land users, including downstream users and fisheries.
	• Flood regulation: functioning wetlands buffer the rise and fall of flood waters.	• Local communities and land users.

	• Biological control of populations of potential pests and disease vectors. • Coastal protection, minimising the impact of natural hazards such as storm surges.	• Local communities and land users. • Local communities and local business.
Supporting services	• Forests and freshwater ecosystems support high levels of biodiversity and endemism.	• All humankind.
Cultural services	• Ecotourism opportunities including initiatives at Loango and Moukalaba-Doudou National Parks (great ape viewing) and across the Gamba Complex (sports fishing, crocodile tours, turtle walks, whale watching). • Scientific values (Gamba Complex is a source of research and data). • Indigenous traditions linked to forest and freshwater.	• Local, national and international tour operators. • Global scientific community, local companies. • Local indigenous communities.

Of particular relevance to later sections of this case study are the ecosystem services related to bushmeat hunting, consumption and trade and ivory trade, and hydrology.

Within the Landscape, rural communities depend on provisioning services provided by the forest, savannah and lagoons for subsistence and trade. Hunting is an important tradition in Gabon, and for much of Gabon is the main source of animal protein (ahead of fishing/ livestock). For urban populations, although reliance on imported food is high, there is a strong cultural preference for bushmeat which drives demand within Gamba town and across major towns in Gabon. Cultural beliefs protect some species to a certain extent, for example customary taboos related to eating chimpanzees exist in parts of Gabon (Strindberg et al., 2018). However, in Gamba town immigrants from across Gabon with different taboos dilute these cultural differences. Although there is customary subsistence hunting permitted within the GCPA, it is primarily professional hunters that are providing meat to the urban centres, using oil and forest roads to hunt game (including duikers, bushpigs, brush-tailed porcupines, crocodiles and mangabeys) - often unsustainably and illegally (The Congo Basin Forest Partnership, 2006). Elephant ivory is also targeted illegally for international trade. Unmanaged, these ecosystem services can threaten and undermine the biodiversity values in the landscape and is often associated with industry impacts.

Water is of significant ecological importance in the Landscape, with coastal savannah, extensive lagoons, inundated forest, swamp, rivers and streams. A study by Goldstein et al. (2017) assessed the potential of the different catchments across Gabon to contribute hydrological ecosystem services of erosion control, nutrient retention and groundwater recharge. Using modelling tools, hydrological ecosystem services priority areas were identified based upon their provision of the highest levels of water quality and quantity

benefits to people. In the Focal Landscape, groundwater recharge was identified as a notable ecosystem service, potentially threatened by development.

A LANDSCAPE UNDER CHANGING PRESSURES

STEP 2
Assessing and understanding landscape: threats and pressures today and in future

STEP 1 | STEP 2 | STEP 3 | STEP 4

Step 2 continues with gathering and analysing information in order to understand sector developments now and in the future, the types of impacts to social and ecological values associated with these sectors and other potential threats and pressures within the landscape.

This section provides a brief summary that contributes to understanding these issues within the landscape.

Threats and pressures

This biodiversity rich multi-use landscape supports oil and gas, commercial forestry, plantation and smallholder agriculture as well as a number of unregulated activities. Individually and together, these have the potential to impact important biodiversity and ecosystem service values. The current status of these and planned developments are outlined below, a snap shot of the current intersecting concessions is shown in Figure 8.

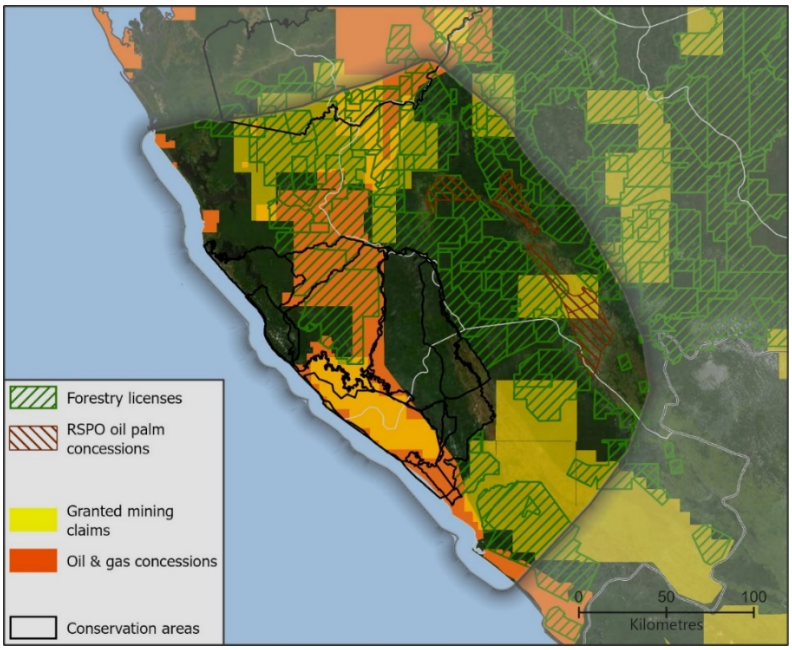

Figure 8 Map of known concessions within the Focal Landscape

Oil and gas

National perspective

Gabon has 2,000 million barrels of proven crude oil reserves and 26 billion cubic metres of proven natural gas reserves (OPEC, 2020; World Bank Group, 2020a). Despite falling production and reserves, the oil sector still accounted for 45% of GDP and 80% of export value over the last five years.

In Gabon's Emerging Gabon Strategic Plan to 2025, oil production continues to play a role, however gas production will be stimulated and will be essential for other targeted industries namely mining, fertiliser and electricity (République Gabonaise, 2012). A new hydrocarbon code (Law 002/2019) aims at providing more attractive investment opportunities for the sector (Norton Rose Fulbright, 2019).

Landscape perspective

Until 2017, the three main upstream producers in Gabon were Total Gabon, Anglo-Dutch Shell Gabon and Anglo-French Perenco Gabon, all of which are, or have been, present in the Landscape. Figure 9 shows the current oil and gas concessions and conservation areas in the Focal Landscape, with Figure 10 showing further detail on the dominant operators. Historically, Shell has been a major operator and key stakeholder in the Landscape since the discovery of Gamba in 1960 (the largest oil field in Gabon at the time) and Rabi in 1985 (the largest oil field in sub-Saharan Africa). In 2017, Shell sold its onshore interests and related infrastructure to Assala Energy (UK) (Shell, 2017). The operations previously owned by Shell are within the sensitive and priority biodiversity area within the Gamba Complex's industrial corridor, Rabi-Kounga also overlaps with the Compagnie de Bois's logging concessions.

Perenco, who acquired Total's onshore assets in 2017, are also active in the Landscape, as are Maurel & Prom (French) who have exploration permits in the south near Mayumba, and in production with Tullow in the north (Maurel & Prom, 2014).

Exploration and production continues both on and offshore with potential new oil and gas discoveries made possible with technological improvements (République Gabonaise, 2020). Oil and gas will remain a potential future threat within the Focal Landscape unless direct, indirect and cumulative impacts are managed and lessons learnt from the experience of industries operating in the sensitive environment of the Gamba Complex are disseminated across all onshore operators.

Of concern for this sector in the Landscape is the recent departure of the larger international companies who can no-longer cost-effectively exploit diminishing reserves and are being replaced by smaller companies who may not be bound by high environmental and social measures driven by reputational risk management or financing regulations (pers.comm. A.Todd 2020).

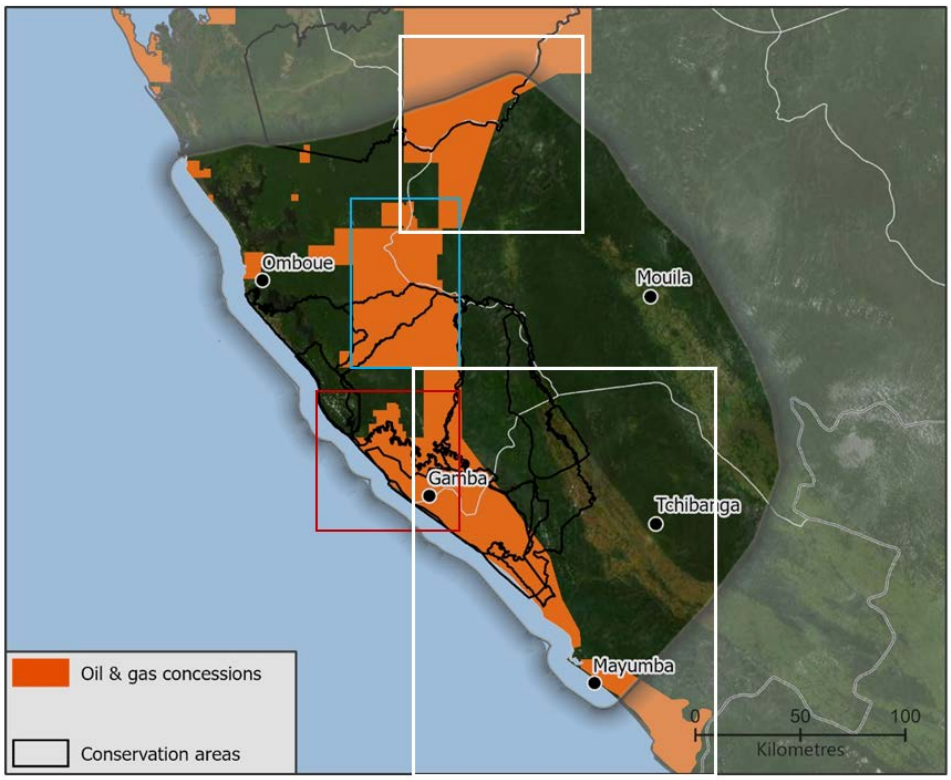

Figure 9 Oil and gas concessions (orange) and conservation areas in the Focal Landscape. See Figure 10 for more detail on the blue, red and white blocks.

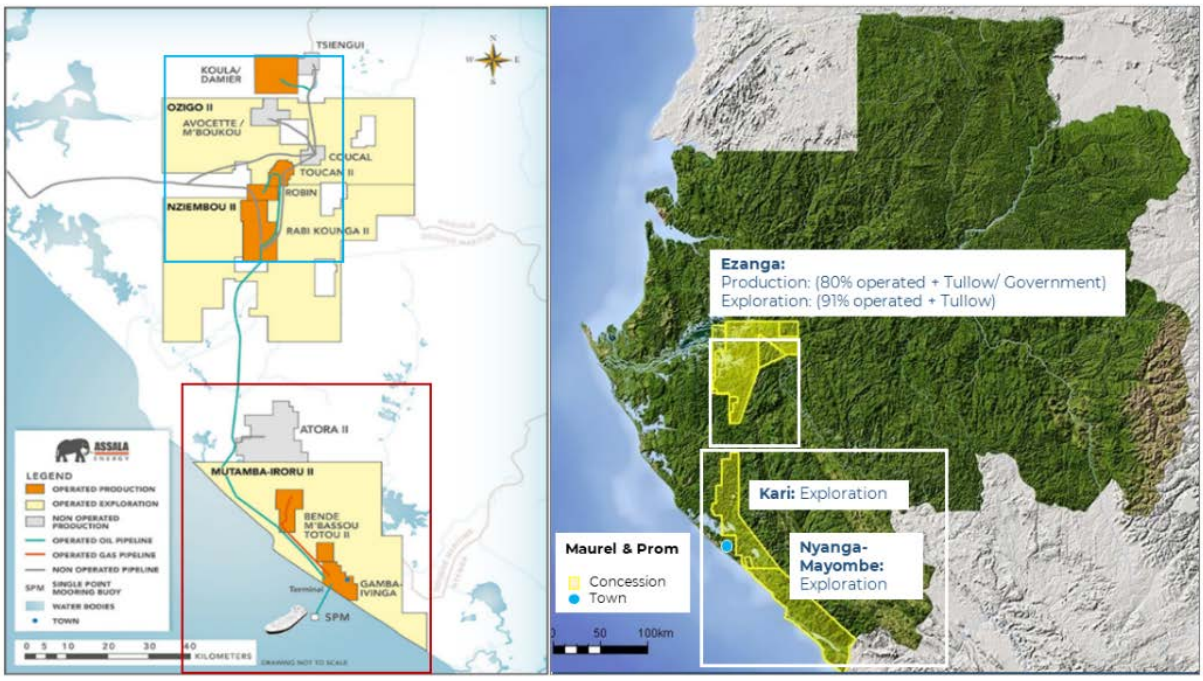

Figure 10 Left shows Assala Energy concessions, with 'Operated Production' sites all previously owned by Shell Gabon. The map also shows Coucal, Avocette and Atora concessions owned by Perenco Gabon (previously Total Gabon). Right shows the production and exploration concessions of Maurel & Prom. Box positions are approximate and relate to the coloured boxes on Figure 9. The northern edge of the GCPA bisects Rabi Kounga to the north. Adapted from: *(Maurel & Prom, 2014; Total, 2017; Shell, 2017; Assala Energy, 2020; Perenco, 2020)*

Forestry

National perspective

Gabon's forests cover over 85% of the country (235,000 km^2), with production forest[4] for wood industry and charcoal production accounting for 63% of the forest area (150,000 km^2) (The Oxford Business Group, 2016). Until 2010, Gabon was a significant exporter of logs, supplying half of Africa's total log exports in 2009, mostly to Chinese and European markets. However, in an effort to add-value through local processing, Gabon abruptly banned the export of logs in 2010, resulting in initial setbacks in the sector. Exports of sawnwood have risen in recent years, and significantly in 2018 due to demand from China. Most of the operational sawmills are now operated by Asian companies. Forestry is selective and habitat conversion limited, however, the sector has experienced overharvesting focusing on a small number of species and illegal logging activity (International Tropical Timber Organization, 2018a)

Sector reforms over the past decade have attempted to balance production with sustainable development. This is highlighted in the revisions to the 2001 Forest Code (in draft) and the Gabon Green Pillar which sets out a plan to increase wood production from less land, reducing the area of production forest to 11 million ha, and at the same time investing capacity and infrastructure for wood processing industries (République Gabonaise, 2012). Special Economic Zones have been set up at locations beyond the Focal Landscape and by 2030, Gabon wants sustainable wood exploitation to replace oil in GDP (Ngounou, 2020). Additionally, by 2022, Gabon will require all logging companies to be certified by the Forest Stewardship Council (FSC) certification scheme (Forest Stewardship Council, 2020).

Landscape perspective

Within the Focal Landscape, forestry concessions cover 48% of the Landscape (see Figure 11). Compagnie de Bois holds the largest area of concessions. Located between the Loango and Moukalaba Doudou National Parks, great apes, leopards, elephants and other important species are found within the concessions.

Other concessions according to the World Resources Institute Global Forest Watch include those held by Corà Wood Gabon (Italy), Société Nationale des Bois du Gabon (SNBG) (National) and Grande Mayumba (located adjacent to Mayumba Town). Grande Mayumba is a 'pioneering model for sustainable green growth' in Gabon, with rights owned by the company African Conservation Development Group, an integrated sustainable land use plan has been developed for conservation, restoration, sustainable forestry (including community forestry), agriculture, rubber, ecotourism and fisheries as well as municipal infrastructure. It is pitched as a de facto pilot for Gabon's National Land Use Plan and follows the principles of the 2014 Sustainable Development Law (African Conservation Development Group, 2020).

[4] All forest is state-owned, management rights are administered by the state to private concessionaires.

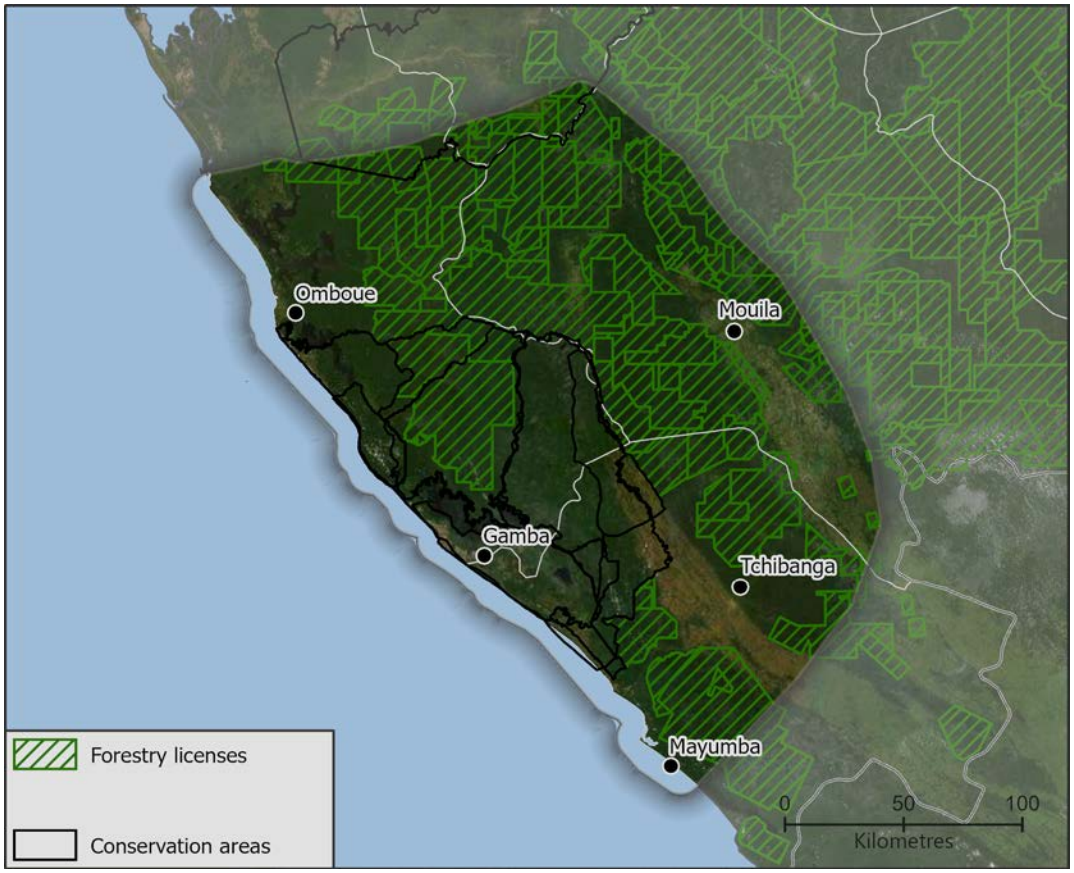

Figure 11 Forestry concessions and conservation areas within the Focal Landscape

Other concessions according to the World Resources Institute Global Forest Watch include those held by Corà Wood Gabon (Italy), Société Nationale des Bois du Gabon (SNBG) (National) and Grande Mayumba (located adjacent to Mayumba Town). Grande Mayumba is a 'pioneering model for sustainable green growth' in Gabon, with rights owned by the company African Conservation Development Group, an integrated sustainable land use plan has been developed for conservation, restoration, sustainable forestry (including community forestry), agriculture, rubber, ecotourism and fisheries as well as municipal infrastructure. It is pitched as a de facto pilot for Gabon's National Land Use Plan and follows the principles of the 2014 Sustainable Development Law (African Conservation Development Group, 2020).

Agriculture

National perspective

The majority of the smallholder farming (0.01-0.02 km^2 or 1-2 ha) is characterised by low yields and is underdeveloped and as such Gabon is food dependent, with most vegetables and starches imported from Cameroon. The government plans to intensify production to achieve food self-sufficiency and to increase GDP from 5% to 20% by 2025 (République Gabonaise, 2015).

At the other end of the scale, government investments in agro-industry in joint venture with multi-national operators has seen growth in livestock and rubber (SIAT Gabon), oil palm (Olam Gabon), sugar (SUCAF Gabon and SFM Africa in the future) and other commodities since the 2000's, building on earlier investments in the 1970/80s.

Gabon has significant agricultural potential estimated at 40,000 km^2 of arable land, of which 10,000 km^2 is exploitable and does not require deforestation (République Gabonaise, 2015). Gabon intends to develop 2,050 km^2 for intensive plant and animal sectors to meet food security objectives, as well as developing 1271.5 km^2 for agro-industrial sectors of palm oil, rubber and sugar with an estimated new land requirement of 580 km^2. For palm oil, it is a promising sign that Gabon is the first country to have adopted the RSPO standard into national policy in 2019 requiring sustainable palm oil development (Roundtable on Sustainable Palm Oil, 2020). Gabon aims to become the second African producer of rubber, third African producer of crude palm oil and a competitive sugar exporter (République Gabonaise, 2015).

Landscape perspective

In terms of the agro-industrial crop development, oil palm is the only commodity currently found within the Focal Landscape. There is no indication that the landscape is to be targeted for development of rubber, sugar or livestock in the future, those industries and associated processing and market chains appear to be developing in other locations (e.g. rubber in the central provinces and sugar in the east). The multinational Singapore-based company Olam dominates the palm oil sector, in joint venture with the Gabon government (Olam Palm Gabon) since 1999. Only one other company, India-based 3F Oil Palm Agrotech, has interests to invest in the sector, signing a Memorandum of Understanding in 2016 to invest $200 million in an integrated oil palm chain with 400 km^2 of plantation, nursery, crude palm oil and kernel mills, a refinery and palm-waste power plant. There is no information on where this will be located (3F Oil Palm, 2020).

Olam operates within the northern boundary of the Focal Landscape, Mouila (lots 1-3) are new plantations since 2016 and Ndende is a smallholder scheme (see Figure 12). There is one mill near Mouila.

It is unclear currently where the intensification of the animal and plant sector to address food security will take place and whether these will be a threat or opportunity within the Focal Landscape. However, Gabonaise des Réalisations Agricoles et des Initiatives des Nationaux Engagés (GRAINE), a smallholder-farming programme launched by SOTRADER (a joint venture between Olam and the Gabon government) is one of the key vehicles for Gabon's agricultural development for rural communities. Its programme of activities focuses on five provinces, with only Ngounié Province intersecting the Focal Landscape, and is the province where Olam has its oil palm plantation (The Oxford Business Group, 2016; World Bank Group, 2020a).

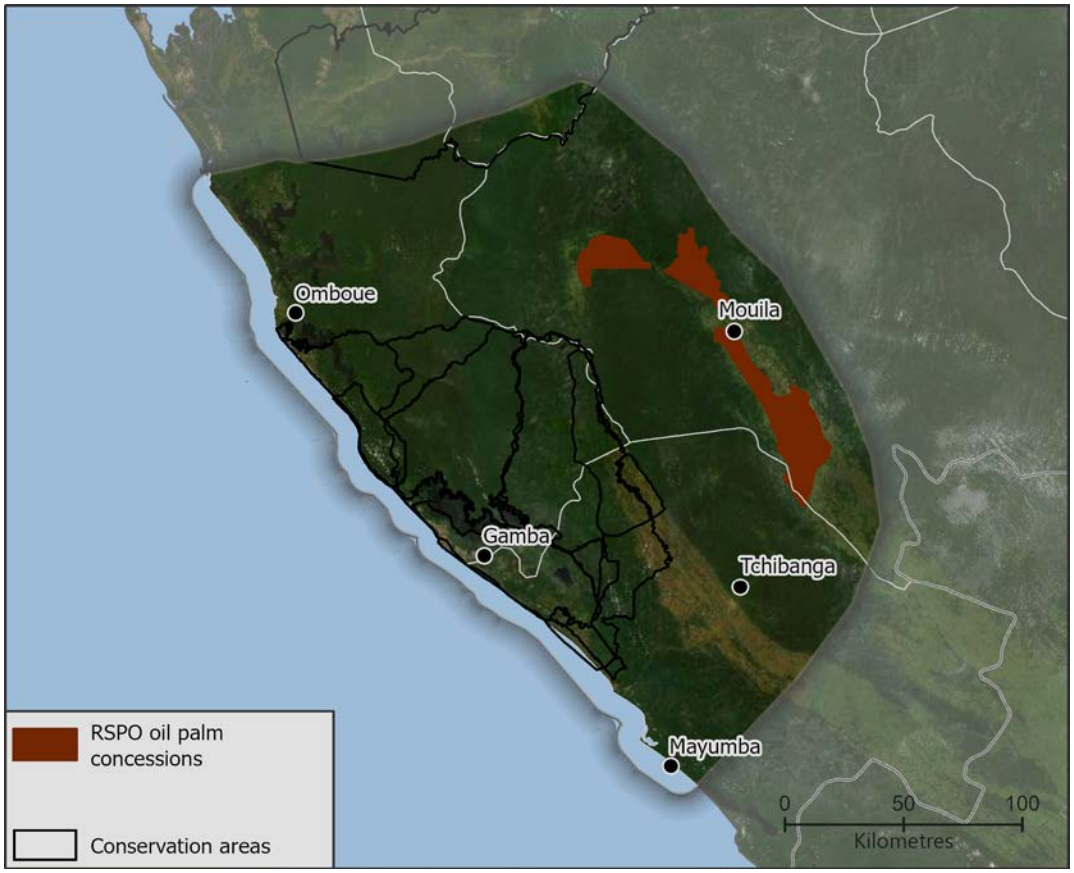

Figure 12 RSPO oil palm concessions in the Focal Landscape (all Olam) and conservation areas

Mining (large-scale and artisanal and small-scale)

National perspective

Gabon has a wealth of mineral resources including gold, manganese, iron, rare earths, phosphate, potash, niobium and precious stones, with manganese, gold and iron considered the three strategic metals; manganese is currently the second most important export after oil. Developing the countries mining potential and developing a clean metallurgy sector is core to the industrial pillar of the Emerging Gabon Strategic Plan to 2025. A new Mining Code in 2015 includes tax and customs incentives, plus improvements to the mining cadastre to support the sector growth (The Oxford Business Group, 2016; Societe Equatoriale des Mines, 2020).

For artisanal and small-scale mining (ASM) of alluvial gold, across Gabon this has historically been associated with informal and often illegal activity depriving the Government of gold related revenue, poor production methods resulting in social and environmental impacts, hunting and land clearance (Hollestelle, 2012). In response, in 2013, the ASM gold industry was restructured in line with the Emerging Gabon Strategic Plan 2025 (République Gabonaise, 2012). The Comptoir Gabonais de Collecte de l'Or, (a wholly-owned subsidiary of Societe Equatoriale des Mines, a private company owned by the Government of Gabon), was established to manage and monitor the ASM gold industry. It's remit includes improving market regulation, providing technical assistance and focusing on environmental protection; the latter in partnership with WWF and the National Agency of National Parks (Societe Equatoriale des Mines, 2020).

Landscape perspective

Figure 13 shows mining claims within the Focal Landscape according to the WWF-SIGHT tool. The claims around the Tchibanga area comprise of exploration licences for high grade iron-ore owned by IronRidge Resources (Australia) (The Oxford Business Group, 2016; IronRidge Resources, 2020). Exploratory activity recently commenced at the Milingui iron deposit, to the west of Tchibanga towards the southern part of Moukalaba-Doudou National Park and is a potential threat to the park (The Congo Basin Forest Partnership, 2006; Havilah Consolidated Resources, 2020). The deposit is estimated at 500 million to a billion tonnes of iron ore (Havilah Consolidated Resources, 2020).

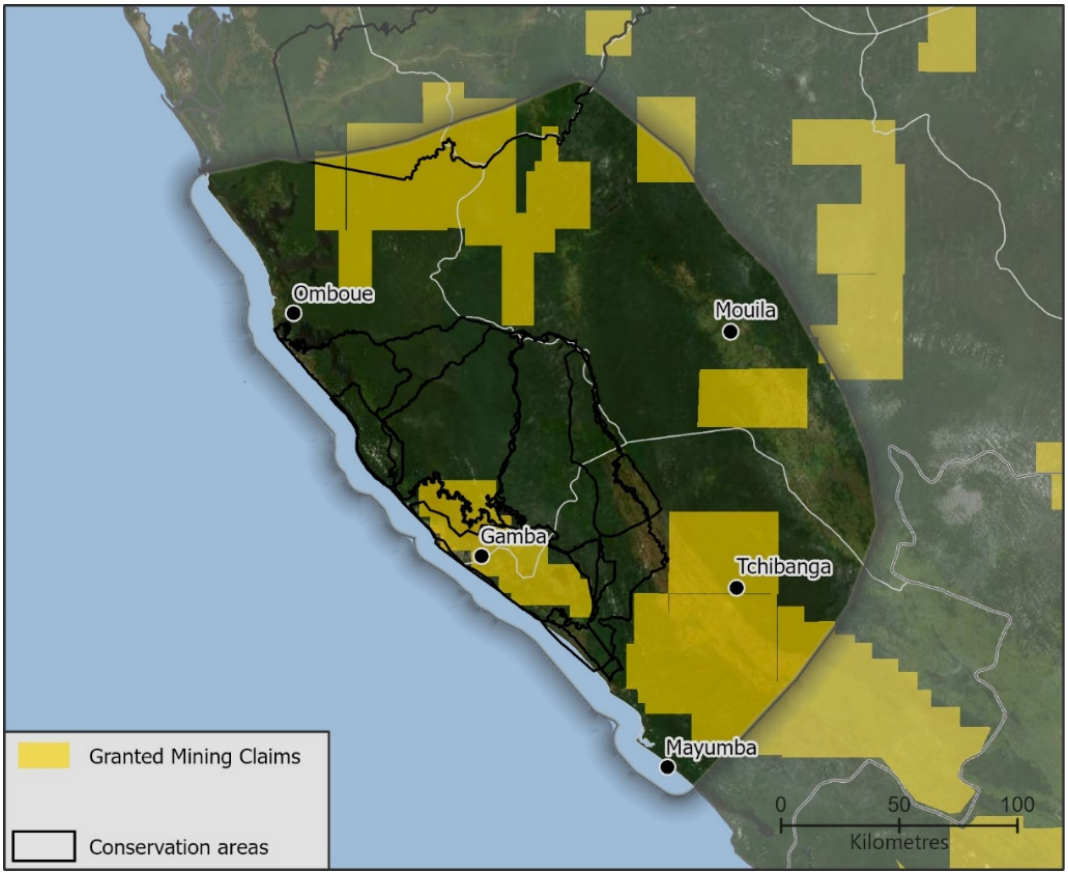

Figure 13 Granted mining claims and conservation areas

Historically, ASM of gold has occurred within Moukoula Doudou National Park, but does not appear to be an issue currently nor raised as an opportunity under the new government programmes (Hollestelle, 2012).

Should any mineral prospecting and exploration sites progress to operation, special attention should be paid to early avoidance of indirect impacts. To date only 30% of the country has been systematically explored therefore there is the potential for more discovery.

Energy and infrastructure projects

National perspective

Oil, gas, wood biomass and hydropower are the main sources of energy in Gabon. Wood biomass accounts for 88% of total energy consumption, as the wood sector grows there is potential to use more waste for energy production. Gabon's domestic electricity

consumption is rising for both industrial and residential use and almost two-thirds of the population now has access to electricity. In 2018, gas constitutes almost 50% of electricity generation, 40% is from hydropower and 10% from oil (International Energy Agency, 2018).

Gas and hydropower will continue to be part of the energy mix into the future. The Emerging Gabon Strategic Plan to 2025 aimed to increase electricity production from hydropower to 80% by 2020. With gas and hydropower eventually replacing petroleum thermal power stations.

Infrastructure development to support the growth of industry is mostly focused on Special Economic Zones which are not found within the Focal Landscape. However, to enable better connectivity and increase economic activity in remote areas across Gabon, the national road network is being upgraded, improving 650 km of road and developing an additional 750 km.

The government has established a system to more effectively channel private sector funds into national development projects, such as road development. Under Law No. 14/74, enacted in 1975, oil companies have the option to pay part of their required income taxes into a public economic development fund for future investments such as the *Provision pour Investissements Diversifiés* (PID), or the *Provision pour Investissements dans les Hydrocarbures* (PIH). The latter being a fund used to finance investments specifically related to the development of Gabon's oil and gas industry (The Oxford Business Group, 2016).

Landscape perspective

Hydropower projects are not found within the Focal Landscape. Gas production is already an existing industry within the Landscape, it will have to meet both export and domestic use and it is unclear if further infrastructure is required for domestic gas transportation. Within the Focal Landscape a number of road improvements are underway or recently completed. This includes:

- Mouila to Ndendé: 75 km road section,
- Ndendé to Tchibanga: 50 km road section
- Bridge on Banyo river near Mayumba,
- Tchibanga to Mayumba road
- Port-Gentil to Omboue road
- Loubomo to Mougarara: 53 km road section crossing sensitive coastal savannah. This was partly funded by Shell Gabon through PID/PHD funds (The Oxford Business Group, 2016). The road links the southern part of the Gamba Complex to the national road network, bringing access to a previously remote priority biodiversity area.

Unregulated development, other threats and pressures

The main threats in the Focal Landscape today are associated with the cumulative and ongoing indirect effects of the oil and gas industry, particularly through induced in-migration and improved access, which catalysed a change to the economic and social patterns within the landscape through the growth of Gamba town (The Congo Basin Forest Partnership, 2006).

Based on global human modification results for 2016 (see Figure 14), human influence is focused around towns, along the national road networks around Mayumba, Mouila, and the oil fields network around Rabi in the northwest/ centre. It is outside of the heart of the protected area system; however, influence is seen at the eastern edges and in the Ramsar site.

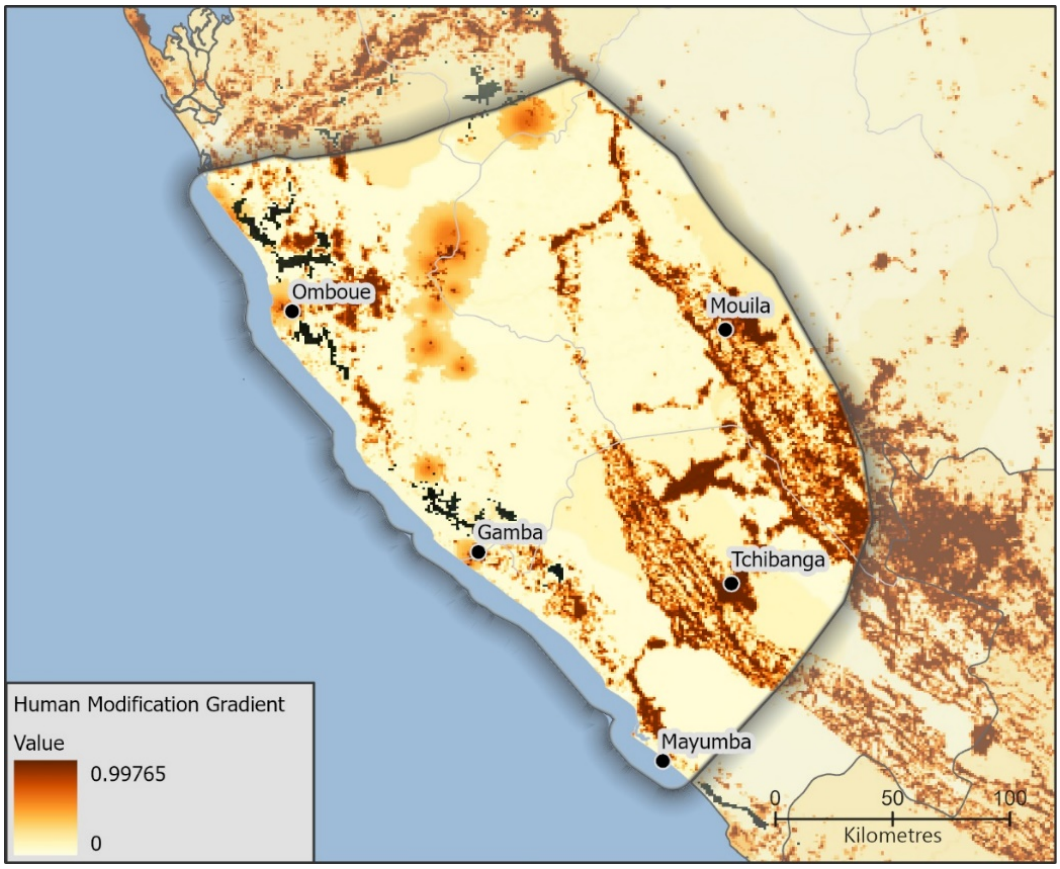

Figure 14 The Human Modification Gradient (2016) represents the level of human influence on biomes (dark colours high influence, light colours low influence)

The main current and emerging threats and pressures to important values from the presence of people include:

- **Unplanned agricultural settlement:** Historically there is little agricultural tradition in Gabon and development of other industries provided more attractive employment. However, agriculture is spreading across the Focal Landscape and it is an important activity for the rural poor, particularly women growing staples such as taro, yams and cassava (The Congo Basin Forest Partnership, 2006; African Commission on Agricultural Statistics, 2019). Unplanned clearance for agriculture, however, threatens much of the habitat outside the National Parks and is causing native vegetation loss and degradation especially along roads (pers. comm. P.B. Maganga 2020).
- **Human-wildlife conflict:** Crop raiding, especially by elephants, is increasing, linked to the expansion of agricultural and leading to conflict (Johnson et al., 2019, pers. comm. P.B. Maganga 2020)**.**
- **Unsustainable and illegal hunting of bushmeat and ivory for consumption and trade:** This is prevalent, enabled through the greater connection to hunting areas provided by road networks and the presence of local (i.e. Gamba and Mayumba

Towns) and long-distance markets. Unemployment has risen around the GCPA since Shell left in 2017 leading to an increasing reliance on bushmeat for consumption and trade. Poaching for ivory is also a threat to elephants in the Landscape (pers.comm. P.B. Maganga 2020).

- **Overfishing in the lagoons:** This is related to the influx of people.

An emerging threat is also posed by climate change. Climate change has the potential to further change interactions between social and ecological systems in the future, potentially placing more demand on natural systems, for example as people adapt through migration or changes in resource use, or through the direct impacts of climate change events. Coastal areas of Gabon, as found in the Focal Landscape, are expected to experience an increase in precipitation while inland areas may experience decreased precipitation, with rainfall variability experiencing increasing intensity and frequency of heavy rainfall. Seasonal flooding, changing rainfall, landslides and extreme winds will affect agriculture, water, energy, oil and mining sectors; flooding is a particularly high hazard across Gabon. The risk of sea-level rise could lead to coastal area flooding and may impact coastal cities as well as oil extraction operations. Temperatures are already observed to be increasing, and in the future will warm faster inland than at the coast with more extreme weather events projected to occur in the near future with impacts to agriculture, water and population health. The poor and elderly are particularly at risk (World Bank Group, 2020a, 2020b).

IMPACT ASSESSMENT, MITIGATION PLANNING AND COLLABORATIVE ACTION

Within the framework, Step 3 focuses on assessment of unmitigated multi-sector impacts and cumulative effects, the incentives for impact mitigation, identification of mitigation hierarchy options and opportunities at landscape and project scales, residual impact assessment and culminates in development of a mitigation plan.

STEP 4
Applying the mitigation hierarchy across a landscape

STEP 1 | STEP 2 | STEP 3 | STEP 4

Step 4 focuses on successful application of the mitigation hierarchy at project and landscape scales supported by collaborative cross-sectoral action to mitigate impacts and contribute towards landscape objectives.

This section explores:

- Impacts: The importance of understanding the social organisation and ecological requirements of priority species in order to assess the likely impacts (direct, indirect and cumulative) that could result from different sectors operating or planned in the landscape
- Mitigation: the need for project and landscape level impact mitigation, the motivation and role of leading companies to follow best practice and engage beyond their concession boundaries to achieve landscape objectives, examples of mitigation and the value of multi-stakeholder collaboration.
- The role of national governance and sustainable landscape level planning in supporting landscape objectives.

Multi-sector impacts

Each of the sectors present or planned in the Focal Landscape has potential to adversely impact biodiversity and ecosystem services if left unmitigated. The wide-ranging impacts of the various sectors are well documented elsewhere (see for example IOGP-IPIECA, 2020 for upstream oil and gas impacts, the World Bank Industry Sector Environmental, Health and Safety Guidelines for impacts related to agriculture (annual and perennial crops), infrastructure, mining and forestry, as well as a background paper related to this project (FFI, 2021b). Within the Focal Landscape, examples of the main potential impacts related to the dominant oil & gas, forestry and palm oil sectors include:

Direct impacts

These include for example (Laurance et al., 2006; World Bank Group, 2007, 2016; Vanthomme et al., 2013; Alonso et al., 2014b; Company X, 2015; Austin et al., 2017; Compagnie des Bois du Gabon, 2020):

- Habitat loss, degradation and fragmentation from production (oil fields, plantation, timber harvesting), roads and infrastructure (including camps, pipelines, wells, mills).
- Noise (e.g. from people and machinery) and light pollution leading to avoidance by animals and reduction in usable habitat.
- Death of fauna by entrapment or road collision.
- Introduction of alien invasive species, e.g. drilling operations can spread invasive fire ants.

- Water quantity and quality deterioration through pollution or disruption to hydrological system e.g. soil erosion from land clearance, roads fragment connectivity between seasonally flooded savannah and lagoons, risk of oil or chemical spills.

Indirect impacts

Indirect impacts are arguably the biggest threats to biodiversity values within the Landscape at present. These are particularly associated with the establishment of concession road networks, increased presence of people and in the case of Shell, the historic growth of Gamba town, and include for example (Laurance et al., 2006, 2009; Vanthomme et al., 2017; International Tropical Timber Organization, 2018; WWF, 2020c and pers.comms. P.B. Maganga 2020):

- Bushmeat hunting and ivory poaching (often unsustainable and illegal), e.g. logging routes open access to forest areas, trucks provide a transport system and camps provide a market.
- Human-wildlife conflict, e.g. human presence due to growth of Gamba town associated with increased agricultural settlement, when crops are grown within elephant migration routes risk of conflict occurrence is high.
- Habitat loss, degradation and fragmentation e.g. due to agricultural land clearance and poaching.

If left unmitigated, the direct and indirect impacts, and the cumulative effect caused by a number of individual operators within one or across multiple sectors can have major consequences for important values in the Landscape.

Species-specific responses to anthropogenic impacts- a focus on great apes and forest elephant

The severity and extent of an industry's impact varies depending on factors including the type of industry, quality of management and type of habitat where the company is operating. Of importance is understanding how a species will respond to any disturbance based on their social and ecological characteristics, and by extension identifying what features needs to be maintained in the landscape to meet habitat preferences in order for a species to thrive (Arcus Foundation, 2014).

In the context of the Focal Landscape, the central chimpanzee and western lowland gorilla are sympatric, occupying to a large extent the same forest areas and often sharing fruiting tree resources, although seasonal overlap in fruit consumption varies greatly (Head et al., 2011) and there are differences in local distribution. Their ability to respond to impacts differs based on the socioecological and their spatial characteristics as summarised in Table 2.

Table 2 Socioecological and spatial requirements of chimpanzee and gorilla (Parnell, 2002; Bermejo, 2004; Cipolletta, 2004; Boesch et al., 2007; Breuer et al., 2009; Emery Thompson, 2012; Arcus Foundation, 2014; Morgan et al., 2018; Robbins & Robbins, 2018; Strindberg et al., 2018; Manguette et al., 2020; Morrison et al., 2020; Seiler & Robbins, 2020)

	CENTRAL CHIMPANZEE	WESTERN LOWLAND GORILLA
Habitat preference	High canopy forest	Mid-high canopy forest with thicker herb layer Savannah-woodland mosaic
Nesting	Preference for trees	Ground and trees
Diet	Specialist, mostly frugivore (seasonal fruiting trees)	Seasonal frugivores, but can shift to an herbaceous diet when fruit is absent.
Daily range	Depends on the season and habitat. 2-3 km – 10 km	Depends on the season and habitat. 1-3 km
Home range (male)	7-41 km^2	6 10-50 km^2
Home range overlap with neighbouring communities and aggressive territoriality	Highly intolerant of neighbouring groups; home ranges are defended by highly territorial males, who may attack or even kill neighbouring chimpanzees	Overlap depending on density. Territorial displays between males over females but otherwise avoidance mechanisms between neighbouring groups, especially when close to core areas
Group format	Clans	Family groups (av. 9)
Male reproductive maturity	8-15 years	18 years
Female reproductive maturity	7-8 years	8-10 years
Inter-birth intervals	5-6 years	4-6 years
Approx. age of first giving birth	10-13 years	10 years
Number of young	1-2 infants per birth/ 1-4 offspring during female lifetime	1-2 infants/ 1-4 offspring during female lifetime
Age of weaning	4-5 years	4-5 years
Infanticide	Yes	Yes

Western lowland gorillas are seasonal frugivores, they prefer an intact forest but will seek areas with a more open canopy (including swamp forest) and will tolerate disturbed forest where herbaceous vegetation grows thickly and can form part of their diet. Unlike other gorillas they include a high proportion of fruit within their diet and when available will select from over 100 species of fruiting trees. Gorillas display variability in nesting depending on various environmental influences, including rainfall, temperature and risk of disturbance from solitary males, predators and other animals, and presence of herbaceous vegetation. In general they have a preference for sleeping in herbaceous ground nests, but will nest in trees (Tutin et al., 1995; Mehlman & Doran, 2002; Rogers et al.,

2004; Takenoshita & Yamagiwa, 2008; Oelze et al., 2014; Strindberg et al., 2018). They are not territorial but groups and solitary males occupy home ranges including suitable habitat, which may or may not overlap, and within which they are able to displace freely with relatively few social restrictions barring those related to inter-unit interactions and the fact that females are always found in groups (Morrison et al., 2020). In the example of logging, Morgan et al (2018) found that by temporarily using refuge areas, gorillas were able to move away from entire logging fronts and able to avoid active timber extraction, recolonising the area immediately after activity ceased, as long as food resources were available.

Gorillas are therefore more adaptable to disturbance than chimpanzees which are specialist frugivores, prefer a more intact forest habitat and prefer high canopy trees for nesting (>15 m). Perhaps most significantly, chimpanzees exhibit aggressive, territorial behaviour which influences their ability to adapt to disturbance and find refugia as it restricts their ability to shift spatial range without dispute (Arnhem et al., 2007; Morgan et al., 2018). For example, for chimpanzees, they can respond to human activities within the group's home range, but where they are forced beyond their home ranges, inter-troop conflict can result in lethal attack. Additionally, if the pushed to use habitat that is suboptimal, limited food resources can lead to stress, malnutrition and impacts to breeding success in the longer-term (Boesch et al., 2007; Kormos & Kormos, 2011). Over the longer term, in the example of logging, the cumulative effects of repeated harvesting cycles of selective logging can change the forest structure to a more open canopy and remove tree species important for dietary fruit. This may not be an issue for generalists, however, may impact to a greater extent the ability of specialists such as chimpanzees to thrive (Morgan et al., 2018).

Species-specific responses to human disturbance and habitat modification are also evident from the impact of roads, villages, infrastructure development, extraction and industrial agriculture on ape density. Chimpanzee densities have been found to increase with distance from roads and villages, whereas gorilla densities showed little response to either (Stokes et al., 2010). However, due to the threat of poaching, one study modelled that where guards are present, the distance to road had no significant influence on chimpanzee density (Strindberg, 2018). Importantly, densities of both subspecies are higher with the presence of guards, high canopy, and where human influence is low, indeed gorillas are at their highest density in guarded protected areas and in sustainably managed Forest Stewardship Council (FSC) -certified logging concessions where suitable habitat and protection from poaching are available (Vanthomme et al., 2013; Strindberg et al., 2018).

Given their long reproductive cycle, great apes are slow to recover when impacts lead to mortality. In addition to direct deaths from poaching or disease, as forest dependent species, the magnitude of negative impacts on apes is greatest when most if not all trees are removed, e.g. for open cast mining, clear-fell logging or agriculture; habitat clearance and ape persistence are incompatible.

As long-lived, wide-ranging species, with specific ecological requirements, forest elephants move along complex corridors of permanent trails daily and seasonally. Using the industrial corridor to pass between the National Parks for food (foraging for leaves, seeds, fruit and tree bark) shelter and water, and accessing the coast for dietary minerals. Fragmentation of the landscape through infrastructure development and agriculture is a major impact, threatening gene flow, population viability, and evolutionary processes in

the long term and the ability to respond to perturbations and access daily and seasonal resources in the short term. Increasing land conversion and settlement within the Landscape increases the risks of human-wildlife conflict as elephant's crop raid for food and face human retaliation. Forest elephants occupy small matrilineal groups, and as such even one death may result in an individual female without a social group (Blake & Inkamba-Nkulu, 2006; Vanthomme et al., 2015). Elephant poaching for ivory is also a threat in the landscape.

It is important to understand how species respond to disturbance and what features need to be retained in the landscape now and in the future for them to meet their lifecycle needs, including habitat preference, dietary and reproductive requirements. Understanding species-specific requirements enables better identification of the range of impacts to the species and enables the design and implementation of appropriate strategies to prevent and mitigate impacts.

Given that these species lifecycles and coping strategies take place across landscapes, it is important to assess impacts in the context of the wider landscape, and in the context of other industry threats and pressures, as this influences the species' ability to respond, adapt and recover. As such, it is necessary to apply mitigation at site and landscape scales.

Mitigation at a project and landscape scale: industry leadership towards landscape conservation objectives

Landscapes are complex, dynamic and adaptive systems and activities in one part of the system can have intended and unintended repercussions throughout the whole system. As such, impacts from development can have wide-reaching implications for species and ecosystems, often beyond the immediate footprint of an activity. In order to improve the likelihood of success of mitigation actions in order to ensure the persistence of biodiversity and ecosystem service values, it is important to apply the mitigation hierarchy at both project and landscape levels. This is particularly the case in order to address threats and impacts to, for example, wide-ranging species utilising different habitats across a landscape, or certain ecological functions and services occurring across large areas (e.g. related to watersheds – see Box 4). In the context of the Landscape, elephants, chimpanzees and gorillas are found both within and outside of the GCPA, it is therefore imperative to employ appropriate land use and management outside of the protected areas network (Strindberg et al., 2018). It is also important to take action at multiple scales in order to deal effectively with issues including, leakage where impacts are effectively addressed in one area but pushed elsewhere in the landscape where protection efforts are lower, managing indirect impacts, and addressing cumulative effects from multiple activities. Project level mitigation actions should align with and contribute towards landscape level issues, targets and outcomes.

Role of industry

All companies must meet legal requirements set out in national policy and regulation (although of course some do not). Where legislation and governance encouraging high social and environmental standards is weak or poorly enforced or monitored, the role of industry to implement best practice is particularly important to help protect important values in the landscape. Where legislation sets high standards (as is the case in Gabon), and is implemented and enforced this provides the enabling environment for continued

best practice and to raise the bar for those companies that do not have voluntary commitments.

The drivers to adopt best practice are various including government regulation, compliance with stringent environment and social criteria to access international financing (e.g. International Finance Corporation's Performance Standard 6) (International Finance Corporation, 2012), voluntary corporate commitments, policy and standards, and responding to consumer pressure and reputational issues (e.g. for deforestation free palm oil).

Within the Focal Landscape, Compagnie de Bois (forestry), Shell (oil and gas) and Olam (palm oil) stand out as leading companies. Their activities within the Landscape show that industrial concessions can be managed sustainably and help support biodiversity objectives outside of the National Parks (Johnson et al., 2019).

Compagnie de Bois is an important player in the sustainable management of the GCPA. As a company, their mission is to operate a model that combines environmental responsibility, development of social benefits for communities, economic sustainability and customer satisfaction. Since its commitment to sustainable development in 2001 and following initial issues implementing the company's 2004 wildlife management plan, Compagnie de Bois have worked in partnership including with WWF, national and local authorities, communities and research institutes to manage their impacts and to make positive contributions to landscape objectives (The Congo Basin Forest Partnership, 2006). This includes establishing a public-private partnership focused on large mammal conservation (PROLAB – Box 2), scientific research blocks and developing a legal land use plan integrating environmental, social and production aspects to guarantee responsible management of the concessions and inform zoning within the wider Gamba Complex (Huijbregts et al., 2009; Compagnie des Bois du Gabon, 2020).

Shell internationally was the first energy industry company to launch a biodiversity standard in 2001, designed in line with international standards, such as the International Finance Corporation. They have made public commitments to not explore or develop in World Heritage Sites, to improve the way they operate in areas of high biodiversity value and to work with others to safeguard protected areas. This includes commitment to applying the mitigation hierarchy and producing biodiversity action plans for environmentally sensitive areas. Working in partnership, Shell Gabon put in place measures to mitigate its direct and indirect impacts as well as to make positive contributions to the broader landscape. Through its support of the Smithsonian Institution's Gabon Biodiversity Program (2000-2017), Shell contributed to an increase in the understanding of biodiversity within the Gamba landscape, influencing industry best management practices, increasing conservation capacity and awareness and fostering multi-stakeholder partnerships (Alonso et al., 2014a; Ikapi, 2016).

Olam globally has a Living Landscapes Policy which supports a 'net positive' approach to sustainable development in agricultural supply chains and landscape management across commodities (Olam, 2018). Olam Palm Gabon has a strong sustainable palm oil policy including no deforestation of High Conservation Value (HCV) or high carbon stock forests and ecosystems, and protection of other HCVs including savannah and wetlands. Olam Gabon have a target of 100% RSPO certification of their operations by the end of 2021 and in 2017 Olam Gabon set a moratorium on greenfield palm development or expansion in its operations until all existing plantations have reached RSPO certification,

given the risks of operation in highly forested countries like Gabon (Olam, 2019). Of Olam's 1639 km^2 area under management within the Focal Landscape, 64% are managed as HCV or buffer zones and management includes landscape approaches to maintain wildlife corridors and protect endangered species including forest elephants and primates. Olam are also investing in smallholders developing a new planting to incorporate cooperative smallholders in Ndende on 100% grasslands. It is necessary to ensure that avoiding forest areas does not come at the expense of rare habitats such as savannah, and to ensure that smallholders have adequate guidelines to ensure high social and environmental standards (Austin et al., 2017), however the Olam Gabon HCV commitment includes both forest and non-forest ecosystems.

Within the Focal Landscape, the most notable changing industry dynamic is within the onshore oil & gas sector. Large, multi-national companies with stringent environmental standards can no-longer cost-effectively exploit diminishing reserves and are making way for smaller companies who may not have the same corporate drivers (e.g. reputational or access to finance) in place to maintain sustainability standards on site or invest in broader conservation initiatives (pers. comm. A.Todd, 2020). It remains to be seen, for example, if Assala Gabon will continue Shell's legacy of environmental responsibility, it is encouraging that the partnership with the Gabon Biodiversity Program has been upheld and a commitment to international best practice standards is in place on the corporate website, although details on actions are lacking. The change in dynamics also increases the risk of indirect impacts to important values as industry related employment opportunities decline, leaving residents to seek income elsewhere. In this context, the role of national government in setting high standards through regulation, oversight and enforcement, and through clear planning that directs where industry and social development activities can occur will be increasingly important.

Mitigating impacts for species and habitats – focusing on great apes and forest elephants

This section focuses in on the two main industries overlapping the conservation areas, forestry and oil & gas, see Table 3 for relevant examples of impact mitigation measures (taken from best practice recommendations and examples used by companies within the Landscape).

In terms of successful impact mitigation for **forestry**, gorillas and chimpanzees can survive in reduced impact and selectively logged forest, if the remaining habitat is a mosaic of primary and secondary forest and other human activity, especially hunting and poaching is prohibited. Well-managed FSC concessions can act as a buffer to National Parks, and protected areas adjacent or close to logging concessions can mitigate the negative impacts of timber harvesting (Morgan et al., 2013; Haurez et al., 2014). Maintaining unlogged forest nearby is particularly important for chimpanzees to meet refuge, nesting and feeding requirements. Only logging part of the home range allowing movement within the range is particularly important to prevent intercommunity aggression leading to population decline (Matthews & Matthews, 2004). For gorillas, who prefer open forest for nesting and the provision of herbaceous dietary staples, as created by selective logging, studies in sustainably managed concessions in southeast Gabon have found the density of weaned gorillas are comparable to estimates in protected areas and the species may even thrive (Haurez et al., 2014).

Gabon has committed that all its forestry concessions will be FSC-certified. Ultimately, monitoring and enforcement will be essential to the success of the commitment. In addition, the availability of best practice guidance, including with an ape focus, supports implementation (Morgan et al., 2013). These guidelines focus on three main threats to apes. That is implementing HCV approaches and monitoring, decreasing the risk of ape-human disease transmission, and strengthening law enforcement within concessions to address poaching (Morgan et al., 2013; Forest Stewardship Council, 2015). To address poaching and protect large mammals within their concession, Compagnie de Bois has established a public-private partnership, PROLAB (see Box 2), in 2008 which has since grown to become a multi-sector platform.

For **oil & gas** Shell Gabon's Biodiversity Action Plan enforces a number of operating procedures to address their impacts, examples employed by Shell on their concessions are included in Table 3 below (Vanthomme, 2012; Ikapi, 2016; Vanthomme et al., 2017).

Despite the anti-poaching measures, poaching and bushmeat consumption have continued on the concession, resulting in further efforts to define best practice mitigation measures for oil & gas companies both on and offsite given that poachers may be deterred from one area through greater restrictions but continue poaching elsewhere such as outside the concession boundary where anti-poaching efforts are lower. The ten recommendations include further restricting access to concessions, promoting offshore inland models (i.e. road-less access) for all new exploration wells, controlling urban and agricultural expansion inside concessions, supporting anti-poaching patrols within the concession and across the landscape, and supporting the creation of a land planning process for the landscape. The latter could build on discussions with local stakeholders and authorities regarding anti-poaching patrols and local urban and agricultural development serving as a platform for creating a landscape land use planning process that incorporates sustainable conservation objectives (see (Vanthomme et al., 2017) for recommendations).

Table 3 Example of impact mitigation measures *(World Bank Group, 2007; Vanthomme, 2012; Morgan et al., 2013; Ikapi, 2016; Vanthomme et al., 2017; Compagnie des Bois du Gabon, 2020; RSPO National Interpretation Working Group 2019-2020, 2020)*

MAIN INDUSTRY IMPACT	EXAMPLE MITIGATION MEASURES
Direct impacts	
Habitat loss, degradation and fragmentation from extraction sites, roads and infrastructure	• Identification of HCV areas, outlining areas for avoidance and conservation management • Maintaining the abundance and distribution of tree species of importance to apes • Set up low-impact forest exploitation, e.g. reduced impact/ select logging. • Maintain unlogged forest near active logging operation. • Limiting the size of platform constructions and use of existing platforms wherever possible for drilling • Road-less access/ reduce the number of roads built and their width. • Road fragmentation mitigation measures (RFMM) applied in areas where animal corridors intersect with roads (see Box 1).

	• Closing old wells and/or restoration of black spots
Noise and light disturbance	• Prevent / minimise noise e.g. rerouting trucks, enclosing machinery e.g. from drill rigs, generators, trucks • Minimise light, e.g. positional lights to direct light only where needed, using minimum light, and warmer colours.
Death of fauna by entrapment or road collision	• Speed controls and road signs
Introduction of alien invasive species	• Not deliberately introduce invasive species • Ensure equipment (e.g. trucks) are washed when moving between areas to prevent the spread of species
Water quantity and quality deterioration	• Limiting soil erosion, e.g. through conservation of banks of rivers and water-courses during exploitation operations • Minimize the number of crossings of watercourses by roads; restrict the slopes of roads to a maximum of 10 % for the actual alignment of the road • Plan and manage the flow of water along the roads (pits and drains)
Indirect impacts	
Poaching	• Prohibition of hunting, fishing and transportation of bush meat and weapons within the concession • Prohibiting access to production areas for unauthorised personnel, and anti-poaching regular patrols • Roads barriers to restrict access • Anti-poaching regular patrols within concession and across landscape (e.g. PROLAB)
Human-wildlife conflict	• Controlling urban and agricultural expansion inside concessions • Contribute data on elephant migration routes for government to include in land use planning process to consider during allocation of agricultural areas.
Habitat loss, degradation and fragmentation	• Controlling urban and agricultural expansion inside concessions • Contributing data that supports government land use planning processes.

BOX 1: BEST PRACTICE APPROACHES TO ROAD FRAGMENTATION FOR WIDE-RANGING MAMMALS

Road fragmentation mitigation measures (RFMM) can be applied in areas where animal corridors intersect with roads, creating and protecting habitat corridors to allow the movement of animals between core habitat areas essential for their persistence. These include road design alterations such as forest canopy bridges, over and under passes for

wildlife, and limiting vehicle speed to reduce collision risk. Modelling is used to identify where wildlife corridors are, however current models include limitations impacting their accuracy. Within the Focal Landscape, the Smithsonian Conservation Biology Institute has explored new methods for modelling which select the most appropriate type of model to fit the field data, use the outputs of the best models to define at a local scale where mitigation should occur and support cost-effective prioritisation considering the constraints faced by road builders. Given the typical costs and difficulties of establishing corridors, empirical model validation should be incorporated in all corridor design projects. Incorporating data gathering for connectivity analysis into Environmental Impacts Assessments and incorporating RFMM into preconstruction design can significantly decrease the cost of mitigation. In the Landscape, the paving of a previous unpaved road connecting Gamba to the rest of Gabon threatens to increase population, hunting, agriculture and disturb animal movements in the GCPA. The analysis targeted forest elephants, buffaloes and apes. The study identified 17.4% of the landscape around Gamba town needs protection, when considering these large mammals. If prioritisation is required, the study recommends focusing conservation efforts in the oil concessions adjacent to Gamba town where significant human disturbance already occurs and represents a barrier to large mammal movement. The recommendation for managing the corridors includes banning deforestation, hunting, snaring, logging and littering, limiting non-timber forest product collection, traffic, and promoting anti-poaching patrols. Infrastructure development should follow the highest standards for avoidance, minimisation, restoration and offsetting and the corridors should be used to inform target areas for restoration and conservation of the local ecosystem (see (Vanthomme et al., 2015, 2019) for methods).

Showcasing the value of multi-stakeholder collaboration – Step 4 in practice

PROLAB and the Gabon Biodiversity Program

Both Shell and Compagnie de Bois have recognised the benefits of collaboration in order to generate a strong science basis to inform their on-site mitigation measures under the project control, but also for enabling a greater chance of success at addressing the major issue of poaching in the Focal Landscape, requiring action beyond one company and one site. The following section touches on these best practice mitigations and provides PROLAB – Box 2 (Projet de Lutte Anti-Braconnage/ Anti-poaching Programme) and the Gabon Biodiversity Program - Box 3 as examples of multisector collaboration for minimisation of indirect impacts to high value priority species.

The Gabon Biodiversity Program, a partnership between the Smithsonian Conservation Biology Institute, Shell Gabon and other stakeholders has been instrumental in defining Shell's appropriate best management practices and for urging other industry operators to take up best practices (Alonso et al., 2014a). The need for best management practices to be shared within and across sectors is imperative in the Landscape, given that major collaborative players such as Shell have transitioned operations to new owners, and given that new sectors are entering the Landscape.

BOX 2: MULTI-STAKEHOLDER COLLABORATION TO SUPPORT MITIGATION - PROLAB

PROLAB was established in 2008 as a tripartite public-private partnership between the Ministry of Water and Forests (MINEF), the World Wildlife Fund (WWF) and Compagnie de Bois. The objectives of the partnership are to fight poaching and protect wildlife within the ecological, industrial corridor between the two Gamba Complex National Parks, an area occupied by the Compagnie de Bois FSC-certified concession, a number of oil exploration permits, and overlapping with Rabi and Toucan oil fields (Morgan et al., 2013).

PROLAB formed following a series of discussions between WWF and Compagnie de Bois starting in 2004. WWF has had a field programme in the GCPA since 1991 and wished to extend their activities to the north of the Complex to better secure the peripheral areas of the Moukalaba-Doudou and Loango National Parks, potentially threated by poaching associated with the presence of Compagnie de Bois's concession. Compagnie de Bois welcomed WWF's proposal, recognising it as a way to achieve its corporate environmental goals related to sustainable management and certification (pers. comm. P.B. Maganga, 2020, email 12 December).

The main activities of PROLAB are education and awareness raising for company employees and neighbouring communities, anti-poaching surveillance and wildlife monitoring and evaluation. In the field, activities are implemented by an independent team headed by a MINEF agent with WWF providing strategic support and expertise, working closely with the National Parks Agency (ANPN). Private sector companies within the complex, particularly forestry and oil companies are members of, and/ or provide financial support to, PROLAB (including Perenco, Maurel & Prom, and historically Shell and Total).

Successful collaboration has been enabled through good partnership management and communication, the definition of clear policies, agreements and commitments between partners, respect of those commitments and transparency. Further enabling factors include the availability of financial resources and the strong human resource capacity, with the core team represented by government, company and WWF staff, and further organisations with strong technical expertise available within the Landscape. The partnership has faced challenges in recent years relating to corruption, wildlife crime and a decrease in funds after the departure of major oil partners (Total and Shell). Building on the strong partnership foundation, these have been overcome by active fundraising and building additional agreements with appropriate resources, for example Conservation Justice, an NGO fighting illegal wildlife activities in Gabon. In 2017-18, PROLAB enlisted the Smithsonian Conservation Biology Institute and WWF to conduct a major wildlife inventory, the largest since 1998-99, to estimate large mammal population abundance and distribution, and gather data on hunting and fishing in the industrial corridor. This major effort has enabled managers across the protected areas and the industrial concessions to adapt their interventions and define new objectives for conservation in the area (per.comm. P.B. Maganga, 2020, email 12 December; (Vanthomme & Nzamba, 2018)).

BOX 3: MULTI-STAKEHOLDER COLLABORATION TO SUPPORT MITIGATION: THE GABON BIODIVERSITY PROGRAM

Since 2000, Shell Gabon has partnered with the Smithsonian Conservation Biology Institute, the Government of Gabon and other stakeholders through the Gabon Biodiversity Program. The Gabon Biodiversity Program grew from an initial request by Shell to conduct biodiversity monitoring and assessments in order to develop Shell Gabon's biodiversity standards in order to manage environmental impacts and to build Shell's environmental awareness. Similar to all NGOs, as a research organisation, careful criteria are defined for collaboration with a corporate entity. Shell Gabon had to meet the Smithsonian Conservation Biology Institute's criteria for engagement including independence for publishing and control of data, a study area with the potential for major contributions to biodiversity, that collaborating partners work towards mutual goals, and that the company follows a plan to conserve biodiversity. The initial assessments provided the first in depth studies of biodiversity across species taxa in the GCPA and found the industrial corridor to be on a par with the National Parks. In response, the Gabon Biodiversity Program was formed. The objectives or the Program are to increase knowledge and understanding of biodiversity in the Gamba landscape through biodiversity research on, and monitoring of, species and habitats of conservation concern; to apply research, conservation, and best-management practices to minimise development impacts on biodiversity; to increase local capacity to sustainably manage natural resources; to raise awareness of the value of Gabon's biodiversity; and to implement partnerships with stakeholders to support biodiversity conservation and sustainable development (Smithsonian Conservation Biodiversity Institute, 2020). As well as Gabon, Smithsonian Conservation Biology Institute has similar collaborations with extractive companies in other countries (mostly in South America) and the benefits of such partnerships have been identified as:

1. Providing the host country with detailed biological information for areas of conservation concern, increasing national biodiversity awareness and capacity, and providing environmental standards for use with other industries.
2. Fulfilling Smithsonian Conservation Biology Institute's mission to understand and sustain a biodiverse planet; generate objective biodiversity knowledge in understudied regions; disseminate gained knowledge and lessons learned; formulate and implement biodiversity monitoring and conservation programs; provide a science-based framework for carrying out biodiversity mitigation, restoration, and offset actions; and support capacity building.
3. The industrial operator increases its ability to document, manage, and reduce environmental risks; attains an impartial, independent, and transparent way of obtaining biological data; uses international standards and best practices to manage biodiversity; and produces results that increase trust among stakeholders.

Over the years, the Gabon Biodiversity Program has made major contributions to biodiversity knowledge (for example understanding the ecological role of the industrial corridor and the impacts of roads and other human disturbance on large mammals), industry best practice in the Landscape, and urging other company managers within the GCPA to use best environmental practices. (Summarised from (Alonso et al., 2014a))

The importance of national governance and sustainable landscape level planning

An engaged multi-stakeholder spatial planning process enables the identification of, and agreement on, the important values to be retained within the landscape and enables the identification opportunities to achiever multiple benefits where possible (see Box 4 for an example related to ecological function and services). The proposed National Land Use Plan is essential to address biodiversity and ecosystem service considerations in the Landscape in order to inform planned developments for new sectors and infrastructure, and imperative for managing the indirect and cumulative impacts which threaten the biodiversity values within the landscape. For example, the plan will enable identifying the most appropriate location for the current spread of subsistence and smallholder agriculture, seeking locations that avoid the chance of human-elephant conflict which can be detrimental to both smallholder crop production and elephants. All though progress is very slow, Gabon is cited as a good example of national land use planning taking wildlife conservation into account.

Strong national legislation, with the appropriate governance and enforcement provides an enabling environment for leading companies to apply best practice, pilot innovative approaches, and to raise the bar for companies who are doing the minimum. It also supports control of indirect impacts such as poaching (through support to law enforcement efforts).

Companies in the Focal Landscape can support the Government in these planning processes and ensure successful implementation by ensuring company concessions are managed appropriately, providing resources, capacity and leadership. For example:

- Compagnie de Bois has a land use plan which is a legal document defining areas for production, protection and agriculture within the concession and integrates social and environmental considerations.
- Olam Gabon has already contributed to the National Land Use Plan under development by sharing information on the agronomic and economic requirements for the development to oil palm and other crops, and by emphasising the environmental and social constraints to be observed in order to comply with international crop sustainability standards (Raison et al., 2015).
- Shell has historically supported the development of conservation plans for nature reserves, which can then feed into landscape scale strategic plans. Supporting NGO and research partners, such as the Smithsonian, to input the essential data needed for informed decisions that take biodiversity and social values into account allowing for the persistence of those values into the future is a key role.

Likewise, the government plan and legislative enforcement will support the management objectives of the companies as well as ensuring appropriate development across the Landscape for the benefit of national development, communities and wildlife into the future.

BOX 4: MITIGATING IMPACTS TO ECOSYSTEM SERVICES – POTENTIAL TRADE-OFFS AND OPPORTUNITIES

Taking a collaborative landscape approach to mitigation planning will be key for maintaining certain ecological functions and services, and can deliver multiple benefits. This is particularly relevant in the case of hydrological ecosystem services. Goldstein et al. (2017) conducted a study which highlighted the importance of groundwater recharge as an ecosystem service in the Landscape. When overlaid with the current forestry concessions, a potential conflict arises between the integrity of the ecological processes that underpin groundwater recharge and land uses that might alter or impede this ecological service (Figure 15). Avoiding and mitigating any impacts to the values which underpin hydrological ecosystem services will promote the integrity and function of these services into the future within a developing landscape.

Moreover, in areas of priority groundwater recharge, there was an overlap between conservation areas and forest carbon stocks (Figure 16). Carbon stocks were represented in Goldstein et al. (2017), with Figure 16 representing the modelled aboveground live woody biomass (megagrams biomass/ ha) by Woods Hole Research Centre (accessed on Global Forest Watch), which roughly translates to half the value of carbon stocks (megagrams carbon/ ha). Some of these priority areas for groundwater recharge also support other ecosystem services, notably priority areas for erosion control, which are identified as priority areas under both the all population scenario and for providing benefits for the rural population only. By avoiding impacts to these priority areas and conserving the ecosystems and processes that support the groundwater recharge ecosystem services, carbon storage co-benefits might be possible in the Focal Landscape area and beyond.

Where impacts in these priority areas cannot be prevented, it is important that the severity and intensity of impacts to hydrological ecosystem services is regulated. Integrated planning frameworks will help ensure that cumulative impacts to hydrological ecosystem services do not exacerbate the impact, in addition to managing the type of developments that may be excluded from implementation in such priority areas. By implementing biodiversity-related offsets within these priority areas, there may be co-benefits to hydrological ecosystem services which in turn will help to prevent future impacts to the hydrological ecosystem services in addition to improving and maintaining the integrity and function of the processes that underpin the service.

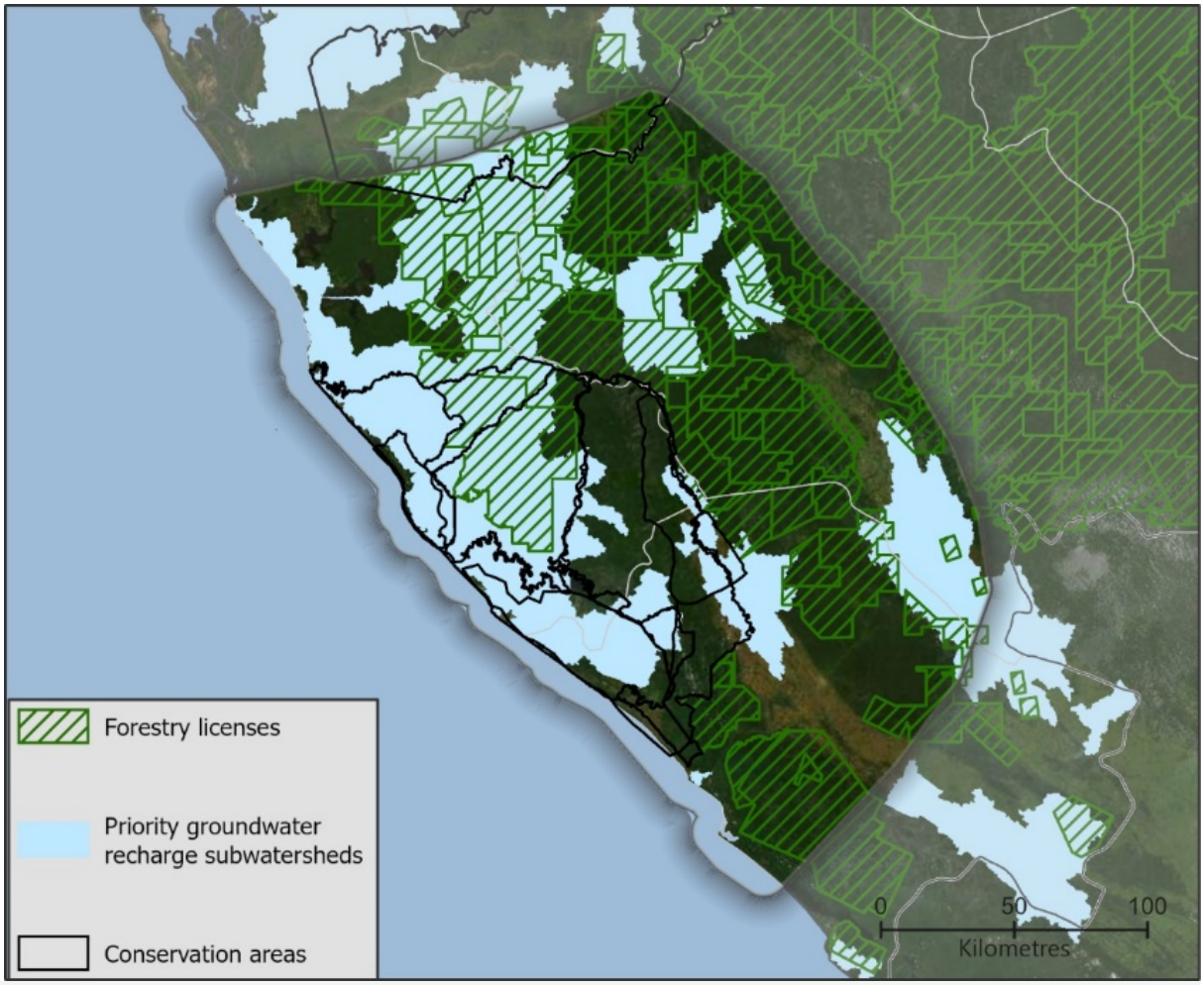

Figure 15 Priority groundwater recharge watersheds and forestry concessions in the Focal Landscape

This supports the recommendations from Goldstein et al. (2017) for the Gabonese national sustainability planning process to consider and include a portfolio of priority areas that support hydrological ecosystem services, as each priority area supports and underpins different services which benefit different demographics (Goldstein et al., 2017).

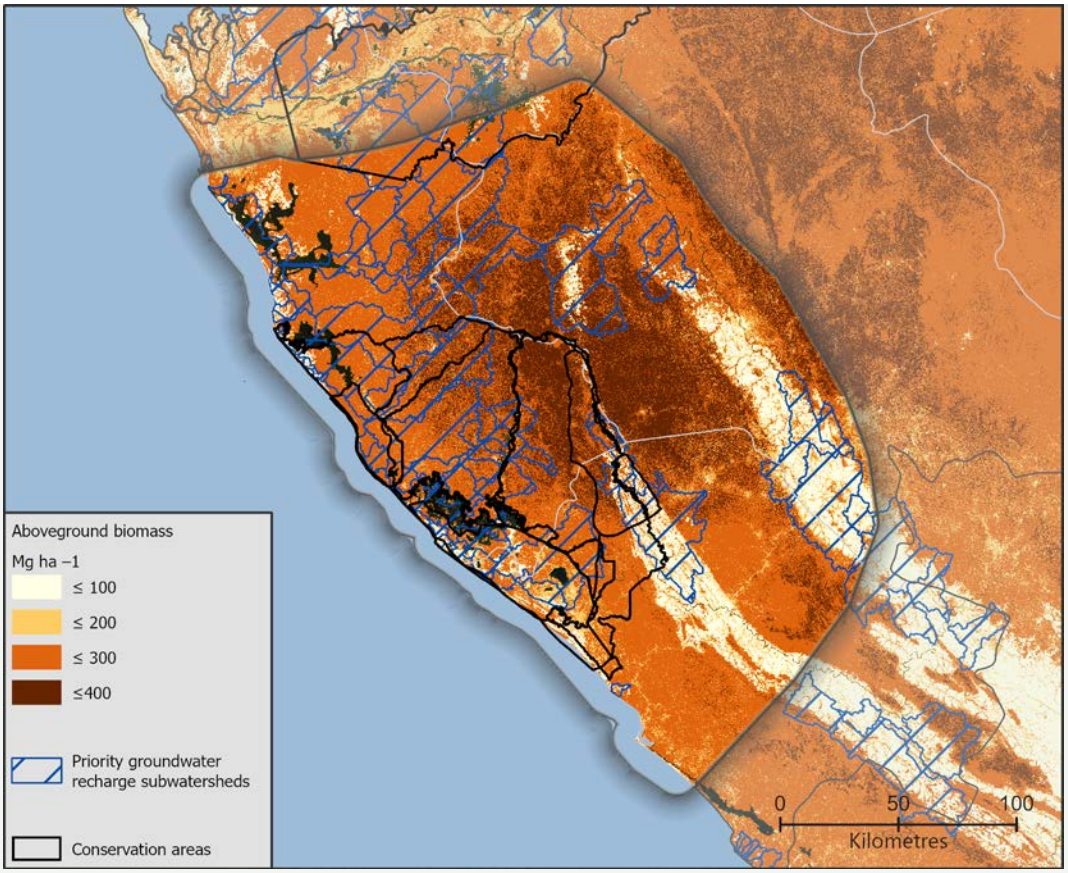

Figure 16 Priority groundwater recharge watersheds, conservation areas and carbon potential

CONCLUSION

The Focal Landscape provides a good example of industry, in partnership with civil society and government actors, developing and applying practices that can avoid and mitigate impacts on the important species, habitats and ecosystem services in order that they may persist and thrive into the future. The proposed national land use level plan will help formalise and gain widespread consensus on the important values that need to be protected both within and beyond the protected area network. The plan will also provide guidance on where development of both industry and agricultural expansion is most appropriate for the benefit of the national economy, people's livelihoods and ecological values, for example minimising crop-raiding by elephants by avoiding elephant migration corridors. The case study has promoted the importance of providing the enabling governance conditions for industry leadership, and where leadership or industry commitment is lacking, enforcement of regulatory requirements to implement good industry practice in impact mitigation. This is especially important during this period of dynamic change.

In the context of the conceptual framework, it is hoped that putting nature and socioecological considerations firmly at the centre of land use and development planning will become the norm, recognising the fundamental role that healthy, resilient ecosystems play in human health, well-being and sustainable development. It is also hoped that the examples from this Focal Landscape will inspire other actors in multi-use landscapes to take up cross-sectoral and collaborative application of the mitigation hierarchy to achieve local and landscape objectives.

REFERENCES

3F Oil Palm (2020) 3F Oil Palm website. Http://3foilpalm.com/about/ [accessed 27 October 2020].

African Commission on Agricultural Statistics (2019) Experience of Gabon in the preparation and implementation of PMRA 2020. Libreville, Gabon.

African Conservation Development Group (2020) Grande Mayumba. Https://africanconservationdevelopmentgroup.com/project/ [accessed 29 October 2020].

Alonso, A., Dallmeier, F., Korte, L. & Vanthomme, H. (2014a) The Gabon Biodiversity Program: A Conservation Research Collaboration. *Africa Today, Special Issue: Narratives of the African Landscape: Perspectives on Sustainability*, 61, 3–15.

Alonso, A., Dallmeier, F., Korte, L. & Vanthomme, H. (2014b) The Gabon Biodiversity Program: A Conservation Research Collaboration. *Africa Today*, 61, 3–15.

Arcus Foundation (2014) State of the Apes: Extractive Industries and Ape Conservation. Cambridge University Press.

Arnhem, E., Dupain, J., Vercauteren Drubbel, R., Devos, C. & Vercauteren, M. (2007) Selective logging, habitat quality and home range use by sympatric gorillas and chimpanzees: A case study from an active logging concession in Southeast Cameroon. *Folia Primatologica*, 79, 1–14.

Assala Energy (2020) Assala Energy Gabon webpage. Https://www.assalaenergy.com/assalagabon/ [accessed 27 October 2020].

Austin, K.G., Lee, M.E., Clark, C., Forester, B.R., Urban, D.L., White, L., et al. (2017) An assessment of high carbon stock and high conservation value approaches to sustainable oil palm cultivation in Gabon. *Environmental Research Letters*, 12. IOP Publishing.

Bermejo, M. (2004) Home-range use and intergroup encounters in western gorillas (Gorilla g. gorilla) at Lossi forest, North Congo. *American Journal of Primatology*, 64.

Birdlife International (2020) Important Bird Areas factsheet: Gamba Protected Areas Complex. Http://datazone.birdlife.org/site/factsheet/6304 [accessed 27 October 2020].

Blake, S. & Inkamba-Nkulu, C. (2006) Fruit, Minerals, and Forest Elephant Trails: Do All Roads Lead to Rome? *Biotropica*, 36, 392–401.

Boesch, C., Head, J., Tagg, N., Arandjelovic, M., Vigilant, L. & Robbins, M.M. (2007) Fatal chimpanzee attack in Loango National Park, Gabon. *International Journal of Primatology*, 28, 1025–1034.

Brand, C.M., Johnson, M.B., Parker, L.D., Maldonado, J.E., Korte, L., Vanthomme, H., et al. (2020) Abundance, density, and social structure of African forest elephants (Loxodonta cyclotis) in a human-modified landscape in southwestern Gabon. *PLoS*

ONE, 15, 1–15.

Breuer, T., Breuer-Ndoundou Hockemba, M., Olejniczak, C., Parnell, R.J. & Stokes, E.J. (2009) Physical maturation, life-history classes and age estimates of free-ranging western gorillas—insights from Mbeli Bai, Republic of Congo. *American Journal of Primatology*, 71, 106–119.

Central African Forest Initiative (2020a) Two New Programmes in Gabon. *6 October*. Https://www.cafi.org/content/cafi/en/home/all-news/reducing-forest-degradation--two-new-programmes-in-gabon.html [accessed 27 October 2020].

Central African Forest Initiative (2020b) Central African Forest Initiative: Gabon webpages. Https://www.cafi.org/content/cafi/en/home/partner-countries/gabon.html [accessed 23 October 2020].

Cipolletta, C. (2004) Effects of group dynamics and diet on the ranging patterns of a western gorilla group (Gorilla gorilla gorilla) at Bai Hokou, Central African Republic. *American Journal of Primatology*, 64, 193–205.

Compagnie des Bois du Gabon (2020) Compagnie des Bois du Gabon webpage. Https://www.cbg-wood.com/en-gb/home [accessed 27 October 2020].

Company X (2015) Unpublished confidential document (in draft).

Dallmeier, F., Alonso, A., Campbell, P., Lee, M.E., Buij, R. & Pauwels, O.S.G. (2006) Ecological Indicators for the Industrial Corridor in the Gamba Complex of Protected Areas : A Zone of High Biodiversity Value and Oil Exploration in Southwest Gabon. *Bulletin of the Biological Society of Washington*, 243–252.

Emery Thompson, M. (2012) Reproductive Ecology of Female Chimpanzees. *American Journal of Primatology*, 75, 222–237.

FFI (2021a) Coordinated and collaborative application of the mitigation hierarchy in complex multi-use landscapes in Africa. A conceptual framework integrating socioecological considerations. Cambridge UK.

FFI (2021b) Applying the mitigation hierarchy in a complex world. Background paper: Multisectoral development and implications for biodiversity and ecosystem services. Cambridge UK.

Forest Stewardship Council (2015) Forest Stewardship Council International Standard: Principles and criterias for forest stewardship.

Forest Stewardship Council (2020) FSC in Gabon: Starting the Journey towards 100% certification. *Forest Stewardship Council webpage*. Https://fsc.org/en/newsfeed/fsc-in-gabon-starting-the-journey-towards-100-certification [accessed 28 October 2020].

Van Gils, E.J.T., Ingram, V.J., Iponga, D.M. & Abernethy, K. (2019) Changes in Livelihood Practices, Strategies and Dependence on Bushmeat in Two Provinces in Gabon. *International Forestry Review*, 21, 108–127.

GOLDSTEIN, J.H., TALLIS, H., COLE, A., SCHILL, S., MARTIN, E., HEINER, M., ET AL. (2017) Spatial planning for a green economy: National-level hydrologic ecosystem services priority areas for Gabon. *PLoS ONE*, 12, 1–21.

HAUREZ, B., PETRE, C.A., VERMEULEN, C., TAGG, N. & DOUCET, J.L. (2014) Western lowland gorilla density and nesting behavior in a Gabonese forest logged for 25 years: Implications for gorilla conservation. *Biodiversity and Conservation*, 23, 2669–2687.

HAVILAH CONSOLIDATED RESOURCES (2020) Havilah Consolidated Resources website. Http://www.havilah-resources.com/works/gabon-iron-ore-project/ [accessed 27 October 2020].

HEAD, J.S., BOESCH, C., MAKAGA, L. & ROBBINS, M.M. (2011) Sympatric Chimpanzees (Pan troglodytes troglodytes) and Gorillas (Gorilla gorilla gorilla) in Loango National Park, Gabon: Dietary Composition, Seasonality, and Intersite Comparisons. *International Journal of Primatology*, 32, 755–775.

HOLLESTELLE, M.R. (2012) Artisanal and Small-scale Mining in and around Protected Areas and Critical Ecosystems (ASM-PACE): Gabon Case Study Report.

HUIJBREGTS, B., LE DUC YENO, S., VANLEEUWE, H., PARNELL, R., STARKEY, R., DEMARQUEZ, B. & DE, A. (2009) Gamba-Mayumba-Conkouati Landscape. In *The Forests of the Congo Basin - State of the Forest 2008* (eds C. de Wasseige, D. Devers, P. de Marcken, R. Eba'a Atyi, R. Nasi & P. Mayaux), pp. 251–263. Publications Office of the European Union, Luxembourg.

IKAPI, M.T. (2016) An Oil and Gas Company Operating in An Area of High Biodiversity - A Model for Sustainable Development and Social Responsibility. In *Society of Petroleum Engineers African Health, Safety, Security, Environment, and Social Responsibility Conference and Exhibition* p. . Society of Petroleum Engineers, Accra, Ghana.

INTERNATIONAL ENERGY AGENCY (2018) International Energy Agency: Gabon profile. Https://www.iea.org/countries/gabon#overview [accessed 29 October 2020].

INTERNATIONAL FINANCE CORPORATION (2012) Performance Standards on Environmental and Social Sustainability. In *IFC's Sustainability Framework* p. .

INTERNATIONAL TROPICAL TIMBER ORGANIZATION (2018a) Tropical Forest Update. In *Tropical Forest Update* p. . Yokohama, Japan.

INTERNATIONAL TROPICAL TIMBER ORGANIZATION (2018b) Biennial review and assessment of the world timber situation 2017-2018. ITTO, Yokohama, Japan.

IOGP-IPIECA (2020) Environmental management in the upstream oil and gas industry. Second edition.

IRONRIDGE RESOURCES (2020) Exceptional First Pass Drilling Results Multiple Broad and High - Grade Gold Drill Intersections Zaranou Gold Project Côte d ' Ivoire , West Africa.

IUCN (2014) Regional Action Plan for the Conservation of Western Lowland Gorillas and Central Chimpanzees 2015-2025. Gland, Switzerland.

JOHNSON, M.B., PARKER, L.D., VANTHOMME, H., TCHIGNOUMBA, L., DEICHMANN, J.L., MALDONADO, J.E., ET AL. (2019) Patterns of genetic diversity in African forest elephants living in a human-modified landscape in southwest Gabon. *Conservation Science and Practice*.

KEY BIODIVERSITY AREAS PARTNERSHIP (2020) Key Biodiversity Areas factsheet: Gamba Protected Areas Complex.

KORMOS, R. & KORMOS, C. (2011) Towards a strategic national plan for biodiversity offsets for mining in the Republic of Guinea, West Africa with a focus on chimpanzees.

LAURANCE, W.F., CROES, B.M., TCHINGNOUMBA, L., LAHM, S., ALONSO, A., LEE, M.E., ET AL. (2006) Impacts of Roads and Hunting on Central African Rainforest Mammals. *Conservation Biology*, 1251–1261.

LAURANCE, W.F., GOOSEM, M. & LAURANCE, S.G.W. (2009) Impacts of roads and linear clearing on tropical forests. *Trends in Ecology and Evolution*, 24, 659–679.

LEE, M.E., ALONSO, A., DALLMEIER, F., CAMPBELL, P. & PAUWELS, O.S. (2006) The Gamba complex of protected areas: an illustration of Gabon's biodiversity. *Bulletin of the Biological Society of Washington*, 12.

MANGUETTE, M.L., ROBBINS, A.M., BREUER, T., STOKES, E.J., PARNELL, R.J. & ROBBINS, M.M. (2020) Female dispersal patterns influenced by male tenure duration and group size in western lowland gorillas. *Behavioral Ecology and Sociobiology*, 74. Behavioral Ecology and Sociobiology.

MATTHEWS, ADELE & MATTHEWS, ANDREAS (2004) Survey of gorillas (Gorilla gorilla gorilla) and chimpanzees (Pan troglodytes troglodytes) in Southwestern Cameroon. *Primates*, 45, 15–24.

MAUREL & PROM (2014) Maurel & Prom Management presentation (Paris). Https://www.maureletprom.fr/en/investisseurs/resultats-presentations/presentations [accessed 11 January 2021].

MEHLMAN, P.T. & DORAN, D.M. (2002) Influencing western gorilla nest construction at Mondika Research Center. *International Journal of Primatology*, 23, 1257–1285.

MORGAN, D., MUNDRY, R., SANZ, C., AYINA, C.E., STRINDBERG, S., LONSDORF, E. & KÜHL, H.S. (2018) African apes coexisting with logging: Comparing chimpanzee (Pan troglodytes troglodytes) and gorilla (Gorilla gorilla gorilla) resource needs and responses to forestry activities. *Biological Conservation*, 218, 277–286. Elsevier.

MORGAN, D., SANZ, C., GREER, D., RAYDEN, T., MAISELS, F. & WILLIAMSON, E.A. (2013) Great Apes and FSC: Implementing 'Ape Friendly' Practices in Central Africa's Logging Concessions. IUCN/ SSC Primate Specialist Group, Gland, Switzerland.

MORRISON, R.E., DUNN, J.C., ILLERA, G., WALSH, P.D. & BERMEJO, M. (2020) Western gorilla space use suggests territoriality. *Scientific Reports*, 10, 1–8.

NGOUNOU, B. (2020) Gabon: Oil will be eliminated from GDP in favour of sustainable timber exploitation. *Afrik21*.

NORTON ROSE FULBRIGHT (2019) Gabon: New Hydrocarbon Code to revitalise the oil & gas sector? Https://www.nortonrosefulbright.com/en-gb/knowledge/publications/83a981a1/gabon-new-hydrocarbon-code-to-revitalise-the-oil-and-gas-sector#:~:text=In order to attract new,2019 (the New Code)).&text=In terms of surface and,different (and lower) levels [accessed 1 December 2020].

OELZE, V.M., HEAD, J.S., ROBBINS, M.M., RICHARDS, M. & BOESCH, C. (2014) Niche differentiation and dietary seasonality among sympatric gorillas and chimpanzees in Loango National Park (Gabon) revealed by stable isotope analysis. *Journal of Human Evolution*, 66, 95–106. Elsevier Ltd.

OLAM (2018) Olam Living Landscapes Policy.

OLAM (2019) Palm Business 2019 Annual Sustainability Report.

OPEC (2020) Organisation of Petroleum Exporting Countries: 2020 Gabon Facts and Figures. Https://www.opec.org/opec_web/en/about_us/3520.htm [accessed 27 October 2020].

PARNELL, R.J. (2002) Group size and structure in western lowland gorillas (Gorilla gorilla gorilla) at Mbeli Bai, Republic of Congo. *American Journal of Primatology*, 56, 193–206.

PERENCO (2020) Perenco Gabon. Https://www.perenco.com/subsidiaries/gabon [accessed 11 January 2021].

PFEIFER, M., LEFEBVRE, V., PERES, C.A., WEARN, O.R. & MARSH, C.J. (2018) Creation of forest edges has a global impact on forest vertebrates. *Nature*, 551, 187–191.

POULSEN, J.R. & CLARK, C.J. (2004) Densities, distributions, and seasonal movements of gorillas and chimpanzees in swamp forest in northern Congo. *International Journal of Primatology*, 25, 285–306.

RAINEY, H.J., IYENGUET, F.C., MALANDA, G.A.F., MADZOKÉ, B., SANTOS, D. DOS, STOKES, E.J., ET AL. (2010) Survey of Raphia swamp forest, Republic of Congo, indicates high densities of Critically Endangered western lowland gorillas Gorilla gorilla gorilla. *Oryx*, 44, 124–132.

RAISON, J., ATKINSON, P., BALLHORN, U., CHAVE, J., DEFRIES, R., JOO, G., ET AL. (2015) The High Carbon Stock Science Study: Independent Report from the Technical Committee; Part 3: Gabon Case Study. The High Carbon Stock Study 2015. Kuala Lumpur.

RÉPUBLIQUE GABONAISE (2012) Plan Stratégique Gabon Emergent Vision 2025 et Orientations Stratégiques 2011-2016.

RÉPUBLIQUE GABONAISE (2015) Plan Opérationnel Gabon Vert: Horizon 2025.

RÉPUBLIQUE GABONAISE (2020) 12th Gabon Shallow and Deep Water Licensing Round.

ROBBINS, M.M. & ROBBINS, A.M. (2018) Variation in the social organization of gorillas: Life

history and socioecological perspectives. *Evolutionary Anthropology*, 27, 218–233.

ROGERS, M.E., ABERNETHY, K., BERMEJO, M., CIPOLLETTA, C., DORAN, D., MCFARLAND, K., ET AL. (2004) Western gorilla diet: A synthesis from six sites. *American Journal of Primatology*, 64.

ROUNDTABLE ON SUSTAINABLE PALM OIL (2020) RSPO BoG endorses Côte d'Ivoire and Gabon National Interpretations of RSPO P&C. *RSPO website*. Https://rspo.org/news-and-events/announcements/rspo-bog-endorses-cote-divoire-and-gabon-nationai-interpretations-of-rspo-pandc#:~:text=In June 2019%2C the Gabonese,RSPO standard into national policy. [accessed 11 January 2021].

RSPO NATIONAL INTERPRETATION WORKING GROUP 2019-2020 (2020) RSPO Principles and Criteria for the production of sustainable palm oil 2018: Gabon National Interpretation.

SACHS, J., SCHMIDT-TRAUB, G., KROLL, C., LAFORTUNE, G., FULLER, G. & WOELM, F. (2020) The Sustainable Development Goals and Covid-19. Sustainable development report 2020. Cambridge.

SEILER, N. & ROBBINS, M.M. (2020) Ecological correlates of space use patterns in wild western lowland gorillas. *American Journal of Primatology*, 82, 1–11.

SHELL (2017) Shell divests Gabon onshore interests. *Shell website*.

SMITHSONIAN CONSERVATION BIODIVERSITY INSTITUTE (2020) The Gabon Program. Https://nationalzoo.si.edu/ccs/gabon-program [accessed 1 October 2020].

SOCIETE EQUATORIALE DES MINES (2020) Societe Equatoriale des Mines website. Http://www.gabonmining.com/component/content/article/12-english/5-a-new-strategy [accessed 23 October 2020].

STOKES, E.J., STRINDBERG, S., BAKABANA, P.C., ELKAN, P.W., IYENGUET, F.C., MADZOKÉ, B., ET AL. (2010) Monitoring great Ape and elephant abundance at large spatial scales: Measuring effectiveness of a conservation landscape. *PLoS ONE*, 5.

STRINDBERG, S. (2018) Guns, germs, and trees determine density and distribution of gorillas and chimpanzees in Western Equatorial Africa. *Science Advances*, 4, eaar2964.

STRINDBERG, S., MAISELS, F., WILLIAMSON, E.A., BLAKE, S., STOKES, E.J., ABA'A, R., ET AL. (2018) Guns, germs, and trees determine density and distribution of gorillas and chimpanzees in Western Equatorial Africa. *Science Advances*, 4.

TAKENOSHITA, Y. & YAMAGIWA, J. (2008) Estimating Gorilla Abundance By Dung Count in the Northern Part of Moukalaba-Doudou National. *African Study Monographs*, S39, 41–54.

THE CONGO BASIN FOREST PARTNERSHIP (2006) The forests of the Congo Basin: State of the Forest 2006. The Congo Basin Forest Partnership.

THE OXFORD BUSINESS GROUP (2016) The Report: Gabon 2016. The Oxford Business Group.

TOTAL (2017) Gabon: Total sells interests in mature fields to Perenco and optimises its operations. *Total website*.

TUTIN, C.E.G., PARNELL, R.J., WHITE, L.J.T. & FERNANDEZ, M. (1995) Nest building by lowland gorillas in the Lopé Reserve, Gabon: Environmental influences and implications for censusing. *International Journal of Primatology*, 16, 53–76.

UNEP-WCMC (2020) Protected Area Profile for Gabon from the World Database of Protected Areas. Https://www.protectedplanet.net/country/GAB [accessed 5 November 2020].

UNESCO (2020) World Heritage Convention: Moukalaba-Doudou National Park. Https://whc.unesco.org/en/tentativelists/2061/ [accessed 27 October 2020].

UNITED NATIONS (2020) United Nations Country Profile: Gabon. Http://data.un.org/en/index.html [accessed 26 October 2020].

UNITED NATIONS DEVELOPMENT PROGRAMME (2019) Human Development Report 2019: beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century. In *United Nations Development Program* p. . United Nations Development Programme, New York.

UNIVERSITY OF MARYLAND (2020) Global Land Analysis & Discovery: Hinterland forests 2013. Https://glad.umd.edu/dataset/hinterland-forests-2013 [accessed 10 October 2020].

VANTHOMME, H. (2012) Impact of roads and other human disturbances on large mammals in the Gamba area (Gabon) – Short report. Washington D.C., USA.

VANTHOMME, H., KOLOWSKI, J., KORTE, L. & ALONSO, A. (2013) Distribution of a Community of Mammals in Relation to Roads and Other Human Disturbances in Gabon, Central Africa. *Conservation Biology*, 27, 281–291.

VANTHOMME, H., KOLOWSKI, J., NZAMBA, B.S. & ALONSO, A. (2015) Hypothesis-driven and field-validated method to prioritize fragmentation mitigation efforts in road projects. *Ecological Applications*, 25, 2035–2046.

VANTHOMME, H. & NZAMBA, B.S. (2018) PROLAB technical report: Abundance and distribution of elephants, great apes, other mammals, gray parrots, and signs of hunting in the industrial corridor of the Gamba Protected Areas Complex.

VANTHOMME, H.P.A., NZAMBA, B.S., ALONSO, A. & TODD, A.F. (2019) Empirical selection between least-cost and current-flow designs for establishing wildlife corridors in Gabon. *Conservation Biology*, 33, 329–338.

VANTHOMME, H.P.A., TOBI, E., TODD, A.F., KORTE, L. & ALONSO, A. (2017) Antipoaching standards in onshore hydrocarbon concessions drawn from a Central African case study. *Conservation Biology*, 31, 696–706.

WORLD BANK GROUP (2007) Environmental , Health , and Safety Guidelines for Forest Harvesting Operations. World Bank Group, Washington D.C.

WORLD BANK GROUP (2016) Environmental, Health, and Safety Guidelines for Perennial Crop Production. World Bank Group, Washington D.C.

WORLD BANK GROUP (2020a) Gabon: Increasing Economic Diversification & Equalizing Opportunity to Accelerate Poverty Reduction. Systematic Country Diagnostic. Washington D.C.

WORLD BANK GROUP (2020b) Climate Change Knowledge Portal: Gabon. Https://climateknowledgeportal.worldbank.org/country/gabon/vulnerability [accessed 30 October 2020].

WWF (2020a) WWF Gamba Complex Programme website. Https://www.wwf-congobasin.org/where_we_work/gabon/gamba_complex_programme/ [accessed 26 October 2020].

WWF (2020b) Atlantic equatorial coastal forest ecoregion. Https://www.worldwildlife.org/ecoregions/at0102 [accessed 10 October 2020].

WWF (2020c) Northwestern Congolian Lowland Forests ecoregion. Https://www.worldwildlife.org/ecoregions/at0126 [accessed 10 October 2020].

DATA SOURCES

DATA LAYER	DESCRIPTION	SOURCE	REFERENCE	LINK TO DATA
Conservation Areas	All nationally declared and legally protected or internationally recognised conservation areas, including National Parks, Classified Forest Reserves, Wildlife Management Areas, Faunal Reserves, Nature Reserves, Hunting Areas and Reserves, Ramsar Wetlands of International Importance, World Heritage Sites and UNESCO Man and Biosphere Reserves. Proposed Protected Areas in Liberia have been accessed through the Forestry Development Authority.	World Database on Protected Areas (WDPA), Forest Development Authority Liberia (FDA)	UNEP-WCMC and IUCN (2020), Protected Planet: The World Database on Protected Areas (WDPA) [On-line], Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net. Liberia Forest Atlas (2019). Dynamic forest monitoring system for Liberia's forest sector: Protected Areas. [ONLINE]. https://lbr.forest-atlas.org/.	https://www.protectedplanet.net/ http://lbr-data.forest-atlas.org/
Key Biodiversity Areas	Sites of global importance to the planet's overall health and the persistence of biodiversity, either coinciding with declared conservation areas or external to the protected area network and supported by the Key Biodiversity Areas Partnership.	Key Biodiversity Areas Partnership	Key Biodiversity Areas Partnership (2020). Developed by the Key Biodiversity Areas Partnership: BirdLife International, IUCN, American Bird Conservancy, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Global Wildlife Conservation, NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, World Wildlife Fund and Wildlife Conservation Society.	http://www.keybiodiversityareas.org/
Land cover	Classified land cover representing the year 2016 at 20m resolution based on 1 year of Sentinel-2A imagery from December 2015 to December 2016. The following land cover classes describe the land surface across the African continent: "trees cover areas", "shrubs cover areas", "grassland", "cropland", "vegetation aquatic or regularly flooded", "lichen and mosses / sparse vegetation", "bare areas", "built up areas", "snow and/or ice" and "open water". In this project's application, this layer has been correlated with the Global Forest Watch forest cover and forest loss layers to update the land cover to the current year 2020.	European Space Agency (ESA)	European Space Agency Climate Change Initiative (2016) "S2 Prototype Land Cover 20m Map of Africa 2016". European Space Agency.	http://2016africalandcover20m.esrin.esa.int/

Tree coverage	Global measure of tree cover percentage at approximately 30 × 30 metre resolution and derived from Landsat imagery for the periods 2000 and 2010. Tree cover is defined as all vegetation greater than 5 meters in height and may take the form of natural forests or plantations across a range of canopy densities.	Hansen/University of Maryland (UMD)/Google/ United States Geological Survey (USGS)/National Aeronautics and Space Administration (NASA), accessed through Global Forest Watch	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342: 850–53.	https://glad.umd.edu/dataset/global-2010-tree-cover-30-m
Tree height	Global measure of tree canopy maximum height (in metres) at approximately 30 x 30 metre resolution using lidar forest structure measurements and Landsat imagery for the year 2019.	Hansen/University of Maryland (UMD)/National Aeronautics and Space Administration (NASA), accessed through Google Earth Engine	P. Potapov, X. Li, A. Hernandez-Serna, A. Tyukavina, M.C. Hansen, A. Kommareddy, A. Pickens, S. Turubanova, H. Tang, C.E. Silva, J. Armston, R. Dubayah, J. B. Blair, M. Hofton (2020) Mapping and monitoring global forest canopy height through integration of GEDI and Landsat data. Remote Sensing of Environment, 112165.	https://glad.umd.edu/dataset/gedi
Habitat function	To perform habitat function connectivity analysis on the land cover layer, Morphological Spatial Pattern Analysis was utilised. Using the connectivity classes of core habitat, edge habitat and bridge habitat, the tool assesses the shape, size and distance of habitat patches using simple mathematical operators. All land cover classes of forest and flooded vegetation were integrated in the habitat layer to which the connectivity was performed.	Joint Research Centre (JRC)	Ostapowicz, K., Vogt, P., Riiters, K. H., Kozak, J. & Estreguil, C. (2008). Impact of scale on morphological spatial pattern of forest. Landscape Ecology, 23:1107–1117.	https://forest.jrc.ec.europa.eu/en/activities/lpa/mspa/
Forest loss	Global measures of tree cover loss at approximately 30 × 30 metre resolution and derived from yearly composites of Landsat imagery. Tree cover loss is defined as “stand replacement disturbance,” or the complete removal of tree cover canopy at the Landsat pixel scale. Tree cover loss may be the result of human activities, including forestry practices such as timber harvesting or deforestation, as well as natural causes such as disease, storm damage or fire.	Hansen/University of Maryland (UMD)/Google/ United States Geological Survey (USGS)/National Aeronautics and Space Administration (NASA), accessible via Global Forest Watch	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342: 850–53.	http://earthenginepartners.appspot.com/science-2013-global-forest

Great ape population density: Central chimpanzee and Western lowland gorilla	Modelled estimated population density values per square kilometre for Central chimpanzee and Western lowland gorilla across their geographic range. Various spatial variables were utilised in the modelling of population densities, including predictor variables derived from site-specific surveys, habitat variables, environmental gradients and anthropogenic and vulnerability variables.	Strindberg *et al.* (2018)	Strindberg, S., Maisels, F., Williamson, E. A., Blake, S., Stokes, E. J., Aba'a, R., ... Wilkie, D. S. (2018). Guns, germs, and trees determine density and distribution of gorillas and chimpanzees in Western Equatorial Africa. Science Advances, 4(4). https://doi.org/10.1126/sciadv.aar2964	https://doi.org/10.1126/sciadv.aar2964
Great ape population density: Western chimpanzee	Modelled estimated population density values per square kilometre for Western chimpanzee across its geographic range. Various spatial variables were utilised in the modelling of population densities, including predictor variables derived from site-specific surveys, habitat variables, environmental gradients and anthropogenic and vulnerability variables.	Heinicke *et al.* (2019)	Heinicke, S., Mundry, R., Boesch, C., Amarasekaran, B., Barrie, A., Brncic, T., ... Kühl, H. S. (2019). Advancing conservation planning for western chimpanzees using IUCN SSC A.P.E.S.—the case of a taxon-specific database. Environmental Research Letters, 14(6), 064001.	https://doi.org/10.1088/1748-9326/ab1379
Habitat suitability	Modelled habitat suitability for Western chimpanzee, African forest elephant and pygmy hippopotamus within the Upper Guinea lowland rainforest extent of West Africa. Derived from analysis using Maxent models and predictor variables of a combination of georeferenced species occurrence data and environmental data, including climatic variables, vegetation and habitat types and precipitation.	Freeman *et al.* (2019)	Freeman, B., Roehrdanz, P. R., & Peterson, A. T. (2019). Modeling endangered mammal species distributions and forest connectivity across the humid Upper Guinea lowland rainforest of West Africa. Biodiversity and Conservation, 28(3), 671–685.	https://doi.org/10.1007/s10531-018-01684-6
Suitable corridors for connectivity	Modelled suitable corridors for Western chimpanzee, African forest elephant and pygmy hippopotamus within the Sapo-Tain and Gola-Ziama forest complexes in West Africa. The least-cost path routes between the established and proposed protected areas within the focal areas were derived from modelling species' dispersal variables and habitat suitability using Circuitscape, Linkage Mapper and Pinchpoint Mapper.	Freeman *et al.* (2019)	Freeman, B., Roehrdanz, P. R., & Peterson, A. T. (2019). Modeling endangered mammal species distributions and forest connectivity across the humid Upper Guinea lowland rainforest of West Africa. Biodiversity and Conservation, 28(3), 671–685.	https://doi.org/10.1007/s10531-018-01684-6

Granted mining claims	Global mining concession dataset, based on the ground covered by a polygon that has been set aside for an activity to take place. This activity could be mining exploration and/or extraction. The dataset utilised in this project is the publically available version, where no interrogation of the data is possible.	SNL Metals & Mining	SNL Metals & Mining, an offering of S&P Global Market Intelligence (2020)	https://panda.maps.arcgis.com/home/item.html?id=6f8e17219c354878af009a6cc9a9f571
Awarded oil and gas concessions	Global oil and gas concession dataset on the location, type, dates and participating companies for all the oil & gas licensed acreage. It also includes applications and some open acreage where country grids defined. The dataset utilised in this project is the publically available version, where no interrogation of the data is possible.	Drilling Info	Copyright Drilling Info, Inc. (2020)	https://panda.maps.arcgis.com/home/item.html?id=2eba17ff88924fa0b08a5c360442ec59
Forestry licenses	Polygons representing the extent of known and active forestry licenses derived from a variety of sources within each of the focal countries.	Liberia: AidData Gabon: Ministry of Forest Economy, Water, Fisheries, and Aquaculture & World Resources Institute	Bunte, Jonas B., Harsh Desai, Kanio Gbala, Brad Parks, Daniel Miller Runfola. 2017. Natural Resource Sector FDI and Growth in Post-Conflict Settings: Subnational Evidence from Liberia. AidData Working Paper #34. Williamsburg, VA: AidData. “Managed forest concessions.” Accessed through Global Forest Watch (2020)	https://www.aiddata.org/data/liberia-concessions-geocoded-research-release-level-1-v-1-0 https://www.globalforestwatch.org
Community forests	Communal Forests are areas set aside by statute or regulation for the sustainable use of forest products by local communities or tribes on a non-commercial basis in Liberia. According to the National Forestry Reform Law of 2006, no prospecting, mining, settlement, farming or commercial timber extraction is permitted on community forests.	Liberia: AidData	Bunte, Jonas B., Harsh Desai, Kanio Gbala, Brad Parks, Daniel Miller Runfola. 2017. Natural Resource Sector FDI and Growth in Post-Conflict Settings: Subnational Evidence from Liberia. AidData Working Paper #34. Williamsburg, VA: AidData.	https://www.aiddata.org/data/liberia-concessions-geocoded-research-release-level-1-v-1-0
Private Use Permits	Private Use Permit refers to a type of framework agreement in Liberia, established in 2006, allowing private individuals to sign contracts with companies for extractive activities. They are approved by the Forest Development Authority. This data set was compiled by AidData who collected the information	AidData	Bunte, Jonas B., Harsh Desai, Kanio Gbala, Brad Parks, Daniel Miller Runfola. 2017. Natural Resource Sector FDI and Growth in Post-Conflict Settings: Subnational Evidence from Liberia. AidData Working Paper #34. Williamsburg, VA: AidData.	https://www.aiddata.org/data/liberia-concessions-geocoded-research-release-level-1-v-1-0

	from Global Witness and the Sustainable Development Institute.			
Oil palm concessions	Displays boundaries of areas of known oil palm plantations for Liberia, compiled by Global Witness from available government maps. Information provided with this data set includes company, ownership group, and land area.	Global Witness	"Oil palm concessions." Accessed through Global Forest Watch	https://www.globalforestwatch.org
RSPO oil palm concessions	This data layer displays the concession boundaries of Roundtable on Sustainable Palm Oil (RSPO) member companies current to the year end 2020, including both certified and non-certified concessions, as well as concessions where the certification status is unknown. The concession boundaries were provided to the RSPO by member companies.	Roundtable on Sustainable Palm Oil (RSPO) Member Companies	RSPO (2020) RSPO Concession. Spatial dataset available from GeoRSPO.	https://rspo.org/members/georspo
Human modification gradient	The global Human Modification map provides a cumulative measure of human modification of terrestrial lands across the globe for the year 2016 at a 1-km resolution. It is a continuous 0-1 metric that reflects the proportion of a landscape modified based on modelling the physical extents of 13 anthropogenic stressors and their estimated impacts using spatially-explicit global datasets with a median year of 2016.	Kennedy *et al.* (2019)	Kennedy, C. .M, Oakleaf, J. R., Theobald, D. M., Baruch-Mordo, S., Kiesecker, J. (2019) Managing the middle: A shift in conservation priorities based on the global human modification gradient. Glob Change Biol. 25:811–826.	https://doi.org/10.1111/gcb.14549
Priority groundwater recharge subwatersheds	Hydrologic ecosystem services priority areas are sub-regions of the country that provide the highest levels of water quantity and quality benefits to people in both urban and rural communities. The assessment focussed on Gabon and modelled the priority subwatershed areas that provide the greatest benefit and support to groundwater recharge processes.	Goldstein *et al.* (2017)	Goldstein, J. H., Tallis, H., Cole, A., Schill, S., Martin, E., Heiner, M., ... Barry Nickel3. (2017). Spatial planning for a green economy: National-level hydrologic ecosystem services priority areas for Gabon. PLoS ONE, 12(6), 1–21.	https://doi.org/10.1371/journal.pone.0179008

Aboveground biomass	Modelled terrestrial aboveground live woody biomass density (megagrams biomass ha-1)at approximately 30-meter resolution for the year 2000, expanding on the methodology presented in Baccini et al. (2012). The data are AGB density values (megagrams biomass/hectare), where aboveground carbon density values can be estimated as 50 percent of biomass density values.	Woods Hole Research Center, Zarin	Woods Hole Research Center. Unpublished data. Accessed through Global Forest Watch Climate	https://www.climate.globalforestwatch.org
Population density	Modelled estimates of the total number of people per square grid across continental Africa, with national totals adjusted to match UN population division estimates and revised to depict year 2012.	WorldPop	United Nations (2015) 'World Population Prospects'	http://esa.un.org/wpp/
Administrative borders	Global administrative data of the international country boundaries and regional boundaries of Guinea, Liberia, Sierra Leone and Gabon.	Global Administrative Areas (GADM)	Global Administrative Areas (2019). GADM database of Global Administrative Areas, version 2.0. [ONLINE] URL: www.gadm.org.	https://gadm.org/
Road network	The Global Roads Inventory Project (GRIP) dataset was developed to provide a more recent and consistent global roads dataset, consisting of global and regional vector datasets in ESRI file geodatabase and shapefile format and derived from a variety of sources including OpenStreetMap.	Global Roads Inventory Project (GRIP) 4	Meijer, J.R., Huijbegts, M.A.J., Schotten, C.G.J. and Schipper, A.M. (2018) Global patterns of current and future road infrastructure. Environmental Research Letters, 13-064006.	www.globio.info
Railway network	The railway key is a label from OpenStreetMap which aims to map and document all types of railways including light rail, mainline railways, metros, monorails and trams.	Open Street Map	Open Street Map. "Key: Railway".	https://wiki.openstreetmap.org/wiki/Planet.osm

Satellite imagery	Imagery of terrain based on various years and imagery sources	Esri, DigitalGlobe, GeoEye, i-cubed, United State Department of Agriculture and Food and Drug Administration (USFDA), Farm Service Agency (FSA), United States Geological Survey (USGS), Aerials Express (AEX), Getmapping, Aerogrid, Institut national de l'information géographique et forestière (IGN), Portuguese Geographic Institute (IGP), swisstopo, and the GIS User Community	Various sources and dates, World Imagery. ESRI.	https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9

Coordinated and collaborative application of the mitigation hierarchy in complex multi-use landscapes in Africa: Gabon

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