PART 3:
Protected areas as life-support systems

How do human societies benefit from African protected areas?

It costs money to maintain a functional system of protected areas, but this investment is not without tangible returns. The following chapters describe:

- How African protected areas maintain the global climate system and mitigate the effects of climate change;
- The way protected areas regulate and improve the supply of freshwater, crucial to local livelihoods and African economies;
- Novel approaches of leveraging protected areas to unlock green economic opportunities in the biodiversity sector.

Women collecting firewood in Sierra Leone.
Source: Annie Spratt on Unsplash, free use under Unsplash License.

3.1 Protected areas and climate change

3.1.1 Protected area coverage of Tropical Moist Forests

Halting and reversing tropical deforestation is key to tackling the twin crises of climate change and biodiversity loss. High-resolution spatial data can help African countries identify nature-based climate solutions based on the most effective combinations of protection, management, and restoration.

The Kunming-Montreal Global Biodiversity Framework explicitly integrates the ambitions of protecting and restoring ecosystems, with fighting climate change[1]. Target 3 of protecting 30% of land and Target 2 of restoring 30% of degraded lands support efforts to reduce and reverse deforestation and forest degradation. Target 8 of minimising the impacts of climate change on biodiversity and building resilience through ecosystem-based approaches also underpins improved forest management and reforestation. Target 10 calls for sustainable management of forestry, agriculture, and other economic sectors, to maintain or enhance both biodiversity and ecosystem functioning, including climate regulation. The expansion of agricultural land for the production of commodities like beef, wood, cocoa, soy, palm oil, coffee, and rubber, is a major driver of deforestation and forest degradation. The European Union is a primary market for these products, so in 2023 the European Union took further steps to regulate imports of commodities produced in ways that affect forests negatively through its Regulation on deforestation-free products[2].

After the Amazon Rainforest, the Congo Basin Forest is the second largest continuous tropical forest in the world. Tropical moist forests of central Africa store significant amounts of carbon because they have the highest biomass per unit area of all tropical forests globally (roughly 420 T/ha), but only 21% is protected[3]. Though Central African forests contribute substantially to climate balance locally, regionally, and globally, deforestation rates remain high.

The high biomass of the Congo Basin Forests.

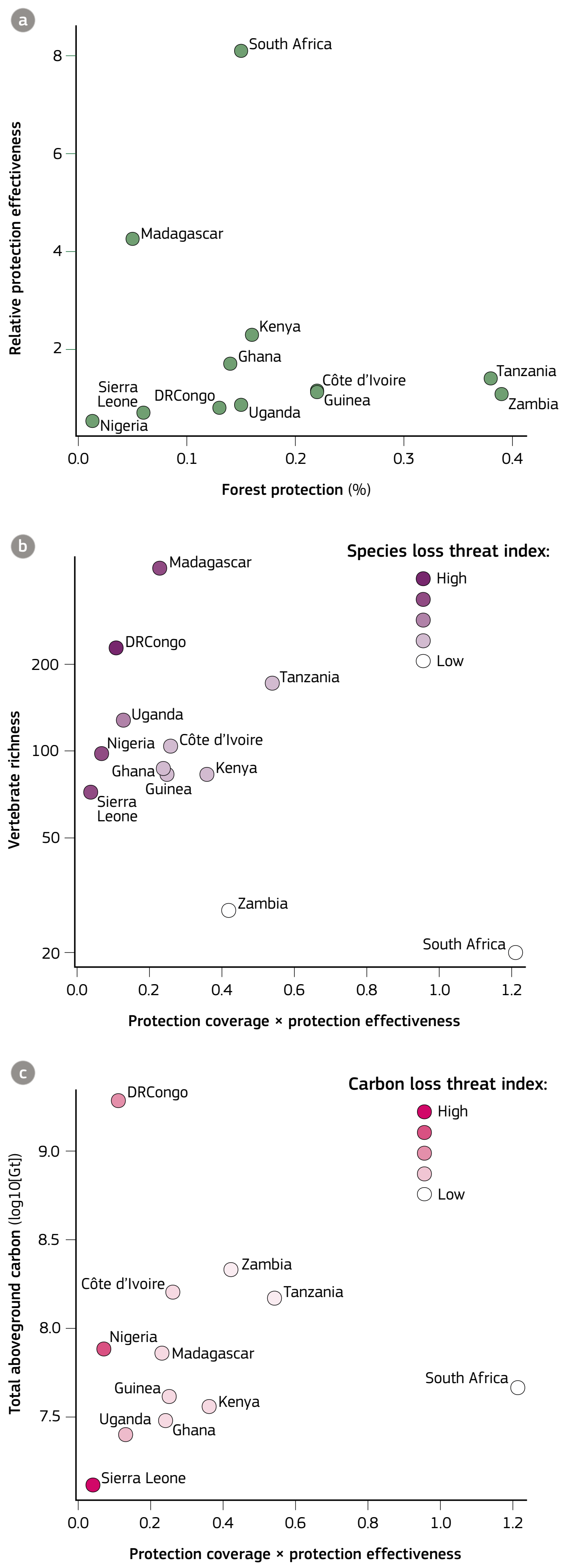
The dense vegetation of the Congo Basin Forests has the highest biomass per unit area of all tropical forests globally.

Even though the value of forests for biodiversity and climate actions is universal, countries would benefit from tailored strategies. A global study quantified the relative mitigation potential of natural climate solutions[4]. For forests, three broad solutions are available to policy officers: avoided forest conversion (i.e. protection), improved natural forest management (i.e. management), and forest restoration (i.e. reforestation). How much to invest in each strategy depends on the relative mitigation potential of each strategy. African countries with the potential to mitigate at least 5 million metric tons of CO_2-equivalents per year from forests show considerable variation in the most effective climate strategies.

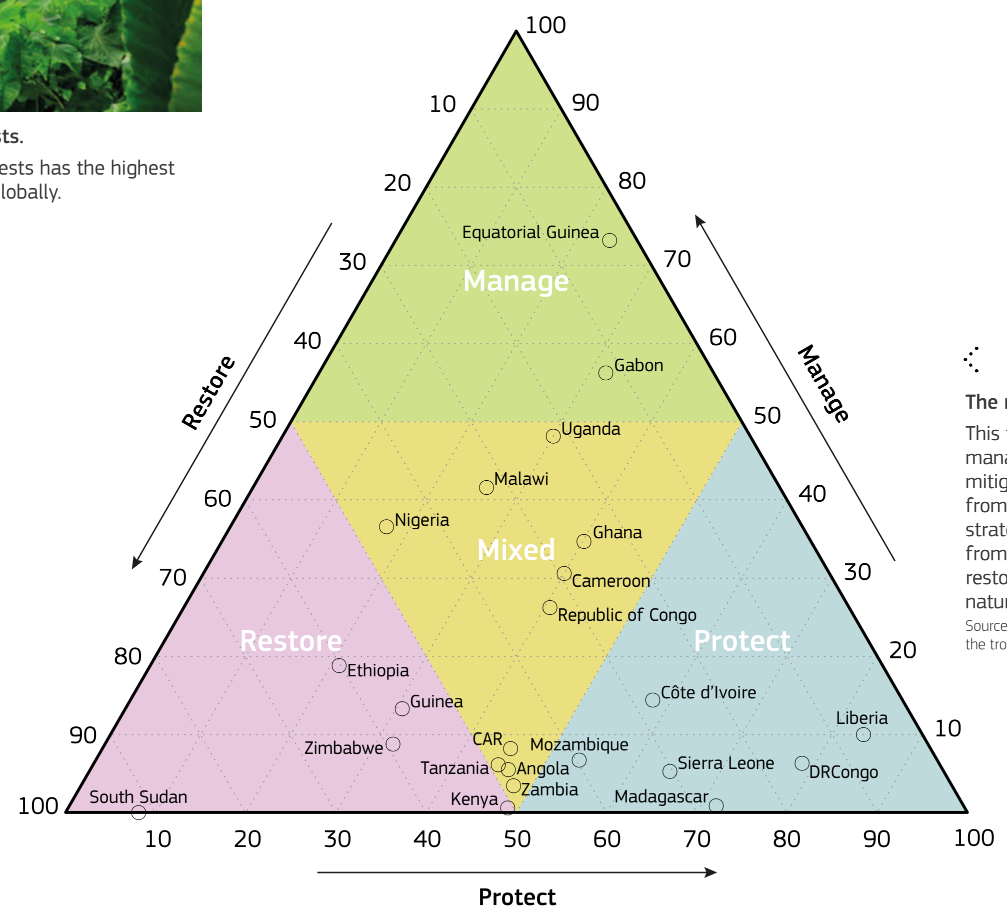
The effectiveness of protected areas at conserving species and aboveground carbon.

Comparing protected and unprotected parcels of land based on statistical matching showed that the effectiveness of protected areas is distinct from the coverage of protected areas. (a) There is no clear relationship between the proportional coverage of forests by protected areas and relative protection effectiveness (i.e. the ratio between forest losses outside vs. inside protected areas). Therefore, the product of protected area coverage and effectiveness is useful for quantifying overall protection. (b) The relationship between the overall protection in a country and the richness of terrestrial forest obligate vertebrates (log-axis). Countries with high vertebrate diversity and low protection effectiveness have a high threat of species loss (darker shades of purple). (c) The relationship between the overall protection in a country and aboveground carbon storage. Countries with high aboveground and low protection effectiveness have a high threat of carbon loss (darker shades of red).

Source: Wolf, C. et al. (2021) A forest loss report card for the world's protected areas. *Nature Ecology and Evolution*, 5, 520–529.



Evaluating the potential of protected areas in limiting deforestation is crucial to climate change mitigation as well as biodiversity preservation. A global study used statistical matching to compare deforestation rates inside and outside of protected areas[5]. This statistical technique identified pairs of pixels with near-identical environmental characteristics (e.g. elevation, slope, proximity to humans), which only differed in their level of protection. This study found that although protected areas did not eliminate deforestation, they slowed deforestation rates. For Africa, reductions in deforestation rates were more evident for stricter (IUCN categories I to IV) protected areas compared to those with less strict (IUCN categories V-VI) protection.



The mitigation options for forest-based natural climate solutions.

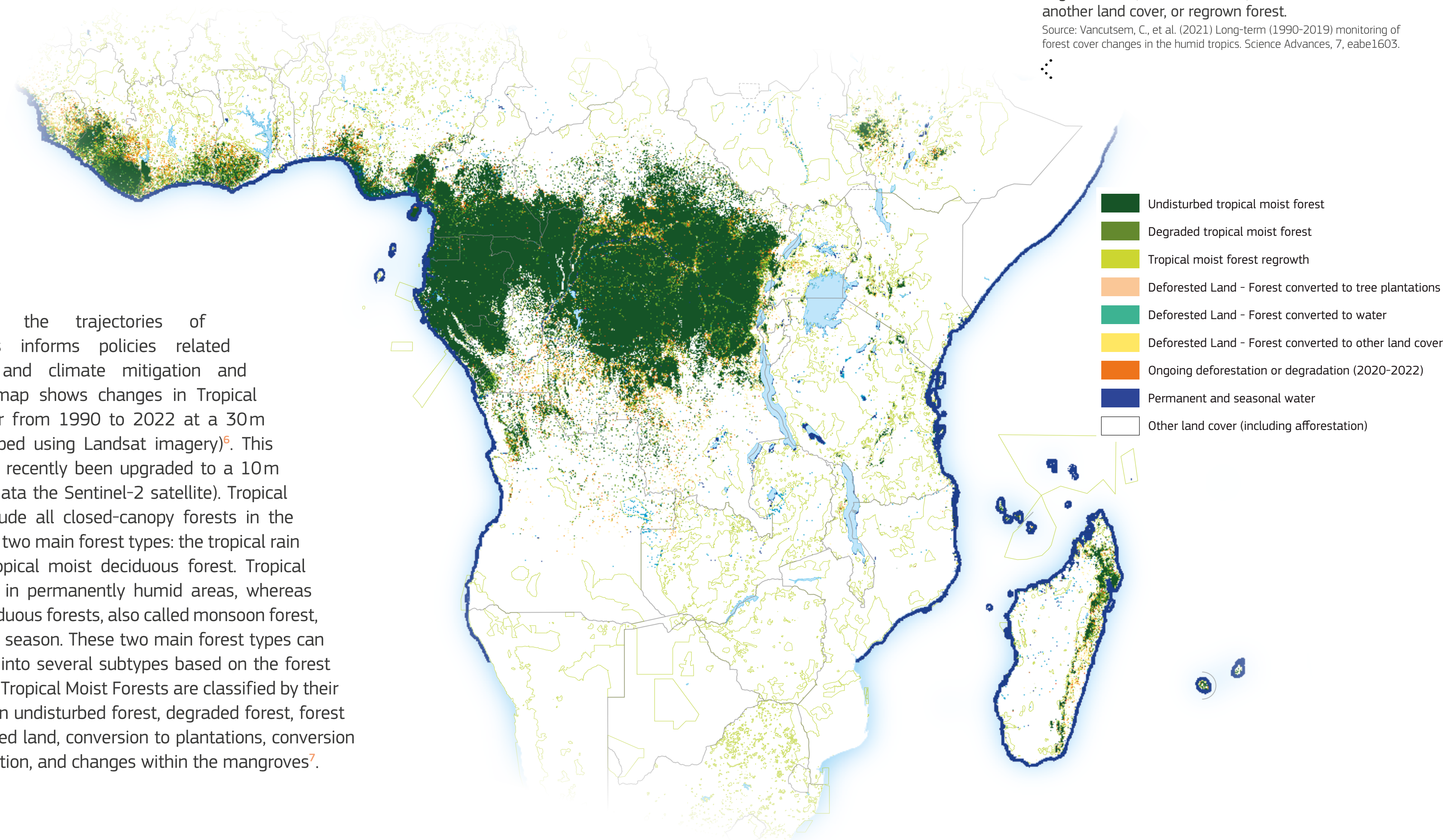
This figure shows the relative mitigation potential for protection, management, and restoration for African countries that can potentially mitigate more than 5 million metric tons of CO_2-equivalents per year from forests. Although many countries would benefit from a mixture of strategies (middle zone), others would have disproportionate benefits from protection (e.g. Liberia), management (e.g. Equatorial Guinea), or restoration (e.g. south Sudan). These strategies exclude the benefit of natural climate solutions in non-forested ecosystems.

Source: Griscom, B.W. et al. (2020) National mitigation potential from natural climate solutions in the tropics. Philosophical Transactions of the Royal Society B, 375, 20190126.

Tropical moist forest transitions.

Pixel-level transitions in tropical moist forests between 1990 and 2022, varying between undisturbed forest, degraded land, deforested land, forest converted to another land cover, or regrown forest.

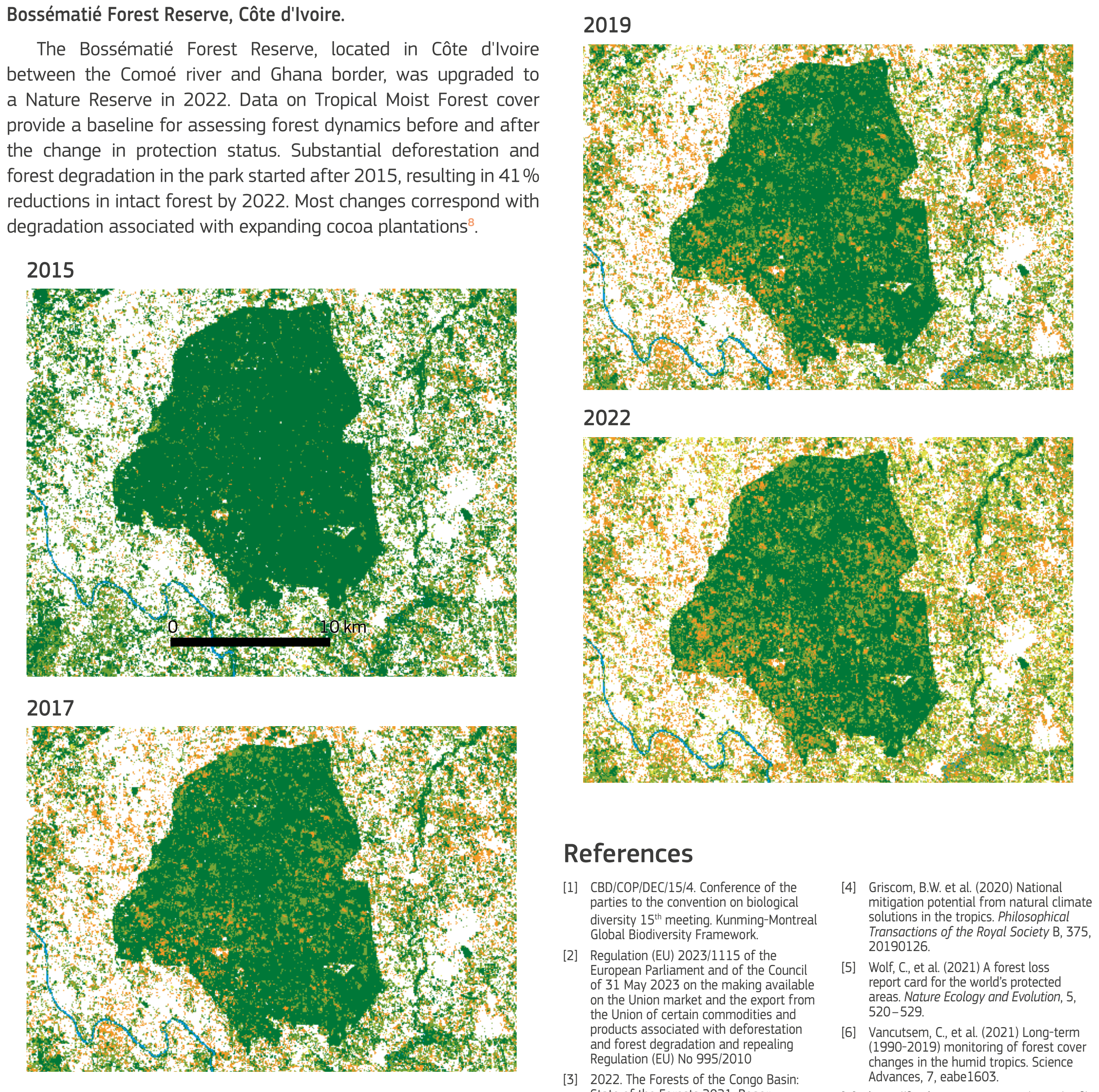
Source: Vancutsem, C., et al. (2021) Long-term (1990-2019) monitoring of forest cover changes in the humid tropics. Science Advances, 7, eabe1603.



Understanding the trajectories of forest transitions informs policies related to conservation and climate mitigation and adaptation. This map shows changes in Tropical Moist Forest cover from 1990 to 2022 at a 30 m resolution (developed using Landsat imagery)[6]. This same product has recently been upgraded to a 10 m resolution (using data the Sentinel-2 satellite). Tropical Moist Forests include all closed-canopy forests in the humid tropics with two main forest types: the tropical rain forest and the tropical moist deciduous forest. Tropical rain forests occur in permanently humid areas, whereas tropical moist deciduous forests, also called monsoon forest, have a distinct dry season. These two main forest types can both be classified into several subtypes based on the forest stage. In this map, Tropical Moist Forests are classified by their transitions between undisturbed forest, degraded forest, forest regrowth, deforested land, conversion to plantations, conversion to water, afforestation, and changes within the mangroves[7].

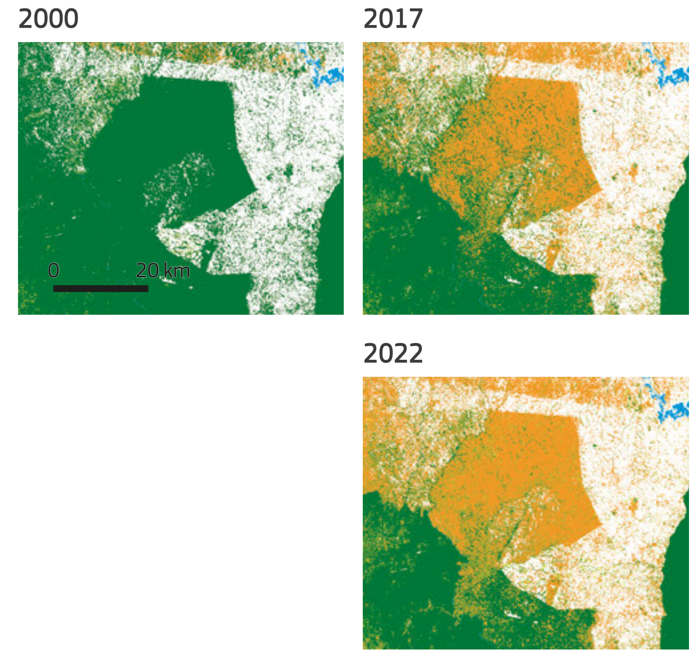
Bossématié Forest Reserve, Côte d'Ivoire.

The Bossématié Forest Reserve, located in Côte d'Ivoire between the Comoé river and Ghana border, was upgraded to a Nature Reserve in 2022. Data on Tropical Moist Forest cover provide a baseline for assessing forest dynamics before and after the change in protection status. Substantial deforestation and forest degradation in the park started after 2015, resulting in 41% reductions in intact forest by 2022. Most changes correspond with degradation associated with expanding cocoa plantations[8].



Goin-Débé and Cavally, Côte d'Ivoire.

Near the border with Liberia, the Ivorian forests of Goin-Débé and Cavally have experienced accelerating degradation since a political crisis in 2011, which was exacerbated by subsequent cocoa plantation expansion[9]. Under the European Union's Regulation on deforestation-free products, selling cocoa from these forest reserves in European markets would be classified as illegal. The value of these remnant forests patches, in particular in relation to the Tai-Grebo-Krahn-Sapo Priority Landscape to the east, triggered efforts from national and international institutions to halt deforestation. Although forest clearing has continued, data indicate that conservation efforts have reduced deforestation by more than 90% since 2017. In September 2023, Cavally Forest was declared as a Nature Reserve.



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[1] CBD/COP/DEC/15/4. Conference of the parties to the convention on biological diversity 15th meeting. Kunming-Montreal Global Biodiversity Framework.

[2] Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010

[3] 2022. The Forests of the Congo Basin: State of the Forests 2021. Bogor, Indonesia: CIFOR.

[4] Griscom, B.W. et al. (2020) National mitigation potential from natural climate solutions in the tropics. *Philosophical Transactions of the Royal Society* B, 375, 20190126.

[5] Wolf, C., et al. (2021) A forest loss report card for the world's protected areas. *Nature Ecology and Evolution*, 5, 520–529.

[6] Vancutsem, C., et al. (2021) Long-term (1990-2019) monitoring of forest cover changes in the humid tropics. Science Advances, 7, eabe1603.

[7] https://forobs.jrc.ec.europa.eu/static/tmf/TMF_DataUsersGuide.pdf

[8] Abu et al., (2021) Detecting cocoa plantations in Côte d'Ivoire and Ghana and their implications on protected areas. *Ecological Indicators*, 129, article 107863

[9] Wild Chimpanzee Foundation (WCF) (2023) Rapport d'observation indépendante externe. Abidjan, Côte d'Ivoire.

3.1.2 Climate services from peatlands

'Peatland' is a general term for land with a naturally accumulated layer of dead and partially decomposed plant remains that have accumulated *in situ* under waterlogged conditions (i.e. peat). Active peatlands, where peat is still forming and accumulating, are known as "mires"[1]. Peatlands provide important habitat for endemic and endangered species, as well as invaluable ecosystem services like storing large quantities of carbon, supplying fresh water, and dampening the flooding effects of heavy rainfall. Degraded peatlands release significant amounts of greenhouse gases, so they play a substantial role in the global carbon cycle[2]. Identifying and mapping peatlands is a key step towards their protection and sustainable management.

Delineating the boundaries of peatlands is sensitive to the choice of inclusion threshold for peatland depth. For example, when using a ≥30cm threshold, Russia's peatlands extend over 139 million hectares. By contrast, a ≥10cm threshold inflates this estimate to more than 368 million hectares[2]. Therefore, maps of peatland extent are fraught with uncertainty. Earth observation shows promise in identifying peatlands over large spatial scales and parts of the world that are difficult to access. However, satellite-based methods cannot measure belowground peat directly, so these techniques must be complemented by ground-truthing field campaigns.

Globally, several spatial products have mapped peatland using different modelling approaches, each with their own strengths and weaknesses. Meta-analysis of regional datasets[3] and machine-learning[4] improve the accuracy of and reduce the divergence between different maps. The feature map shown here is from the Global Peatlands Map (GPM)[5] used in the 2022 Global Peatlands Assessments (GPA)[2]. It is the outcome of a decade-long effort to compile more than 200 datasets, and then supplementing these existing data with information from field mapping campaigns to fill data gaps. According to this map, peatlands cover nearly 40 million hectares throughout Africa (8% of global coverage), storing about 37000 Mega tonnes of Carbon (6% of global storage).

Even though global peatland maps continue to improve, high-resolution regional maps offer the accuracy needed to inform policy and management. Nowhere is this more apparent in Africa than the Cuvette Centrale peatland of the Congo Basin, the world's largest tropical peatland. A recent study published in 2022 presented new *in situ* data on peat presence, thickness and carbon density (mass per unit area) collected between 2018 and 2020 in the Republic of the Congo and the neighbouring Democratic Republic of the Congo[6]. This study specifically investigated river-influenced swamp forests, an improvement on earlier studies that only focused on interfluvial basins. The new data meant that estimates of the extent of peatlands increased by 15%. Estimates of the total amount of carbon stock in the Congo Basin was similar to previous figures (29.0 vs. 30.6 PgC)[7], but the new study reduced uncertainty around these estimates. Reduced uncertainty rules out any remaining doubts of the massive carbon storage potential of central Congo peatlands.

Protected areas cover approximately 35% of African peatlands, a higher percentage than the global average of 18%, but only 11% of Cuvette Centrale is protected[8]. More than 90% of African peatlands are still classified as undisturbed, which allows room for enforcing protection and sustainable management. However, peatland degradation is accelerating, leading to the emission of roughly 130 Mt CO_2e per year. Ten nations are responsible for 59% of these emissions.

Major drivers of peatland degradation are draining driven by agriculture, forestry, and urbanisation, and peat extraction for energy and agricultural use[2]. Emergent threats in the Congo Basin include logging, palm oil concessions, hydrocarbon exploration, and mining[8]. Although knowledge of African peatlands has grown in recent years, there are still important gaps in understanding how future climate change and hydrology will affect the dynamics of these important ecosystems and whether they will continue providing habitat and climate services well into the 21st century[8].

The Cuvette Centrale peat swamp forests, Democratic Republic of the Congo.

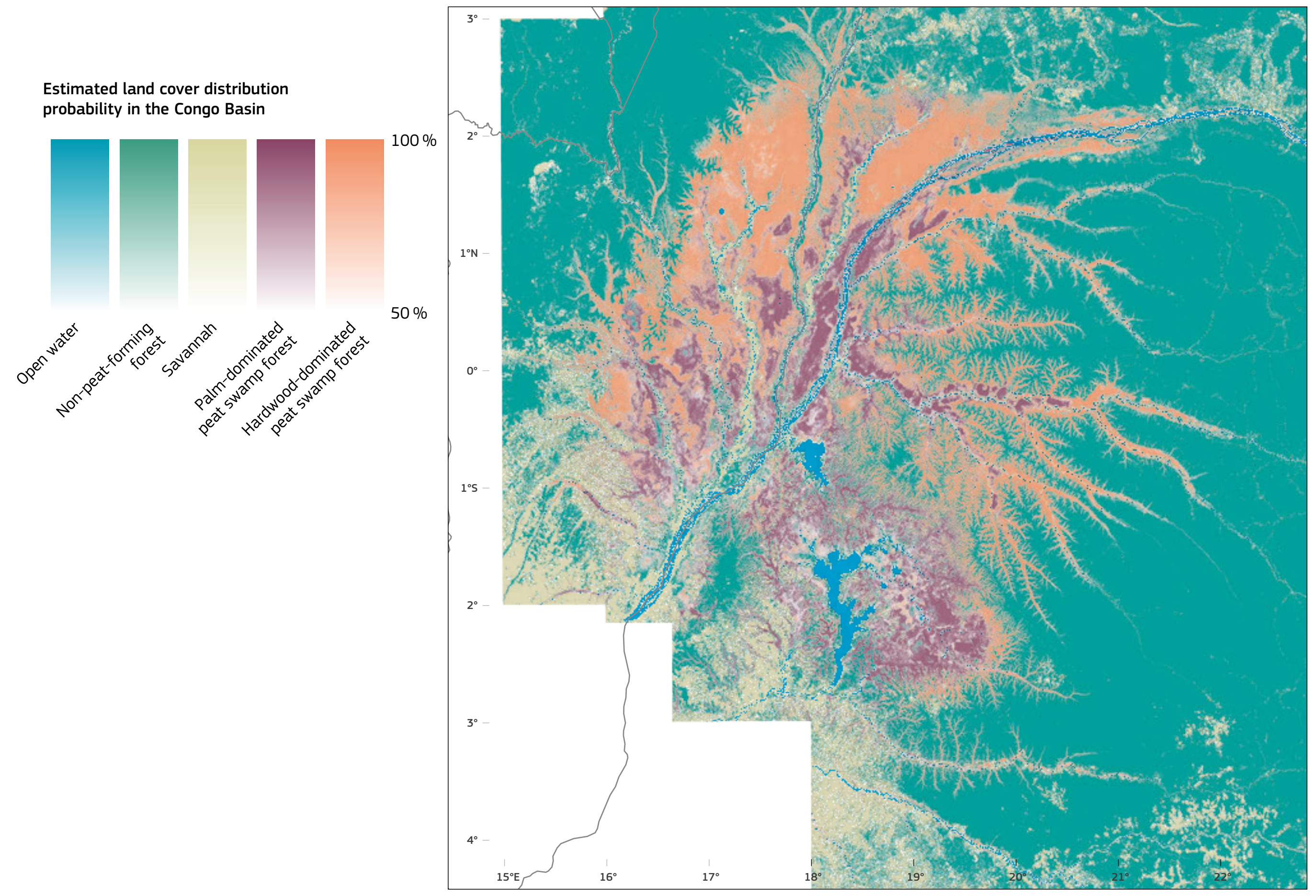
Swamp forests in the Congo Basin provide habitat to populations of lowland gorilla, bonobo, forest elephant, and dwarf crocodile.

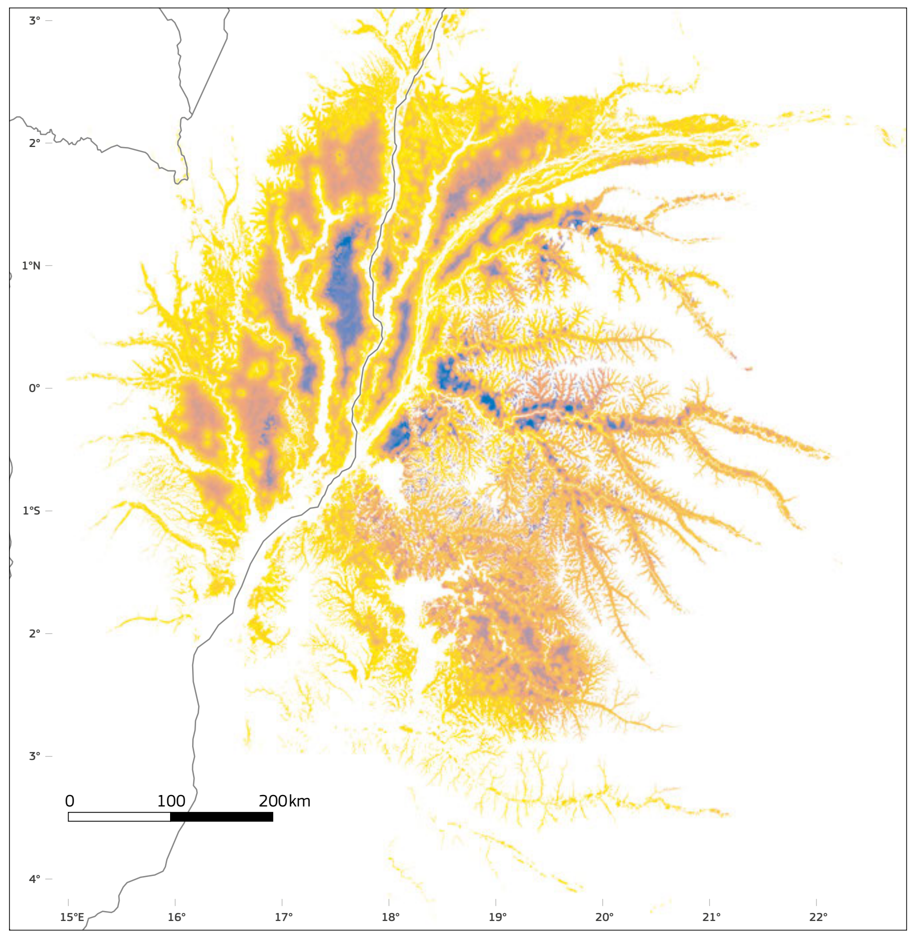
Source: Quentin Jungers, with permission, all rights reserved.

Flooded forests of the Congo River Basin.

Peatlands, swamps, and flooded forests provide significant water regulation services. Losing these ecosystems would not only jeopardise water supply, but also increase the risk of flash flooding downstream due to the reduced water retention.

Source: Quentin Jungers, with permission, all rights reserved.





The belowground peat carbon density in the Congo Basin.

Estimated distribution of palm- and hardwood-dominated peatlands in the Central Congo Basin and the associated belowground peat carbon density (MgC ha^{-1}).

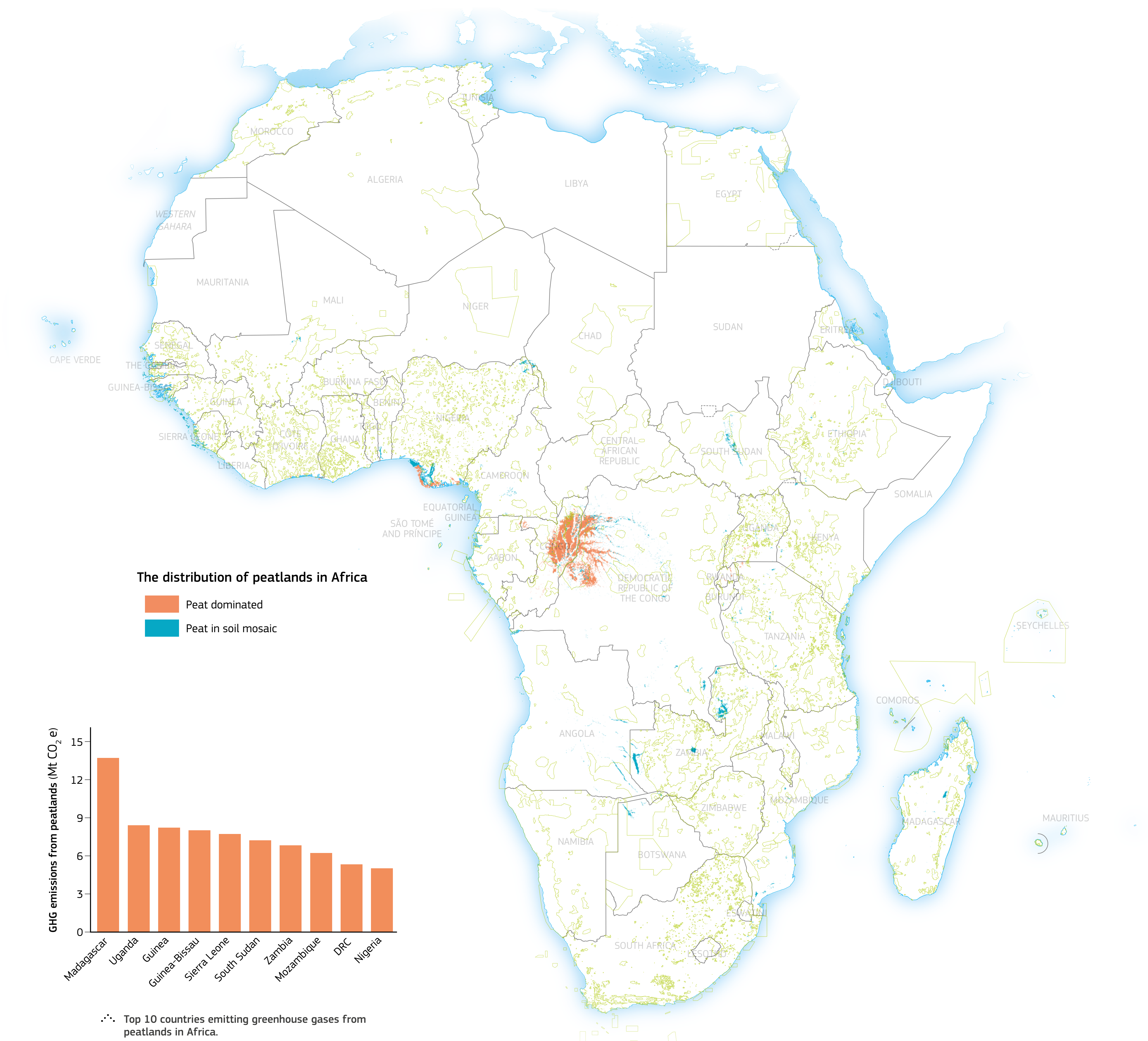
Source: Crezee, B., et al. (2022) Mapping peat thickness and carbon stocks of the central Congo Basin using field data. *Nature Geoscience*, 15, 639-644.

The distribution of peatlands in Africa.

This map shows the distribution of peatlands in Africa, combining country-level peatland maps and high-resolution peatland proxy data from the Global Peatland Database (GPD). Shown are two coarse categories of the dominance of peatland in the soil profile based on expert judgement.

Source: Gumbricht, T. et al. (2017) Tropical and Subtropical Wetlands Distribution, V7. Center for International Forestry Research (CIFOR): https://doi.org/10.17528/CIFOR/DATA.00058

Peatlands cover just 3% of global land surface yet store approximately one-third of Earth's soil carbon. African peatlands represent 8% of the world peatland area and are being degraded at a growing rate. There is an urgent need to protect, restore, and sustainably manage African peatlands.



Top 10 countries emitting greenhouse gases from peatlands in Africa.

These 10 countries account for 59% of the total emissions from peatlands on the continent. In Africa, emission statistics include former peatlands identified from legacy soil maps, where so much peat has been lost that these areas no longer appear in contemporary peatland maps (e.g. in Madagascar).

Source: UNEP (2022). *Global Peatlands Assessment – The State of the World's Peatlands: Evidence for action toward the conservation, restoration, and sustainable management of peatlands. Summary for Policy Makers*. Global Peatlands Initiative. United Nations Environment Programme, Nairobi, Kenya. [Data retrieved from the Global Peatland Database compiled by the Greifswald Mire Centre.]

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[4] Melton, J.R. et al. (2022) A map of global peatland extent created using machine learning (Peat-ML). *Geoscientific Model Development*, 15, 4709–4738.

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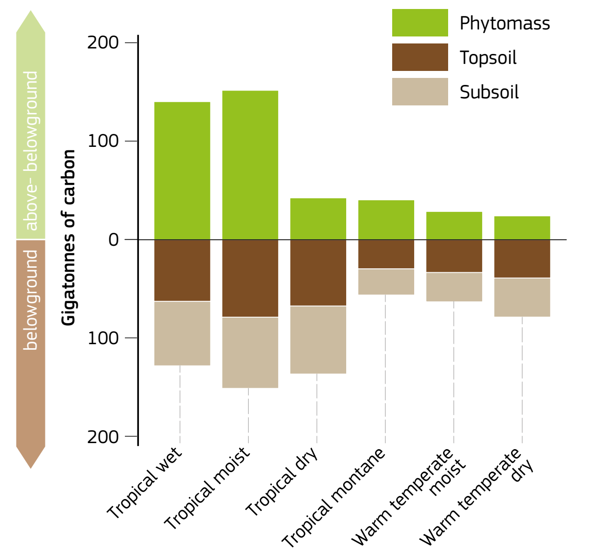
3.1.3 Protected areas and carbon stocks and fluxes

Carbon sequestration and storage are both important ecosystem services for climate regulation and climate change mitigation. In Africa, the challenge of conserving and restoring these services is to manage competition with alternative biomass uses, such as for timber, fuelwood, or charcoal production.

Carbon is an essential element in the organic molecules that make life possible. However, carbon dioxide and related greenhouse gases contribute to climate change. Nature plays a pivotal role in regulating the climate by drawing down carbon dioxide through photosynthesis and locking it up in plant tissue.

Various quantities of carbon are stored in different "stocks" or "pools" globally[1]. The continental crust and upper mantle of the earth is by far the biggest carbon pool (more than 120 million gigatonnes of Carbon, Gt C), followed by the deep and intermediate ocean (37 100 Gt C). Carbon from these two sources are relatively stable because they were built up over millennia (e.g. geological sedimentation and inorganic dissolve carbon). By comparison, the atmosphere contains an estimated 839 Gt C, which is considerably less than the sum of carbon in the surface ocean (900 Gt C), permafrost (i.e. frozen soil: 1 600 Gt C), and soil and vegetation (2 300 Gt C). Soils contain roughly 3 000 Gt C, of which nearly half (1 325 Gt C) is in the topmost 1 m of soil. Forest ecosystems account for 92 % of terrestrial carbon biomass. These carbon pools are more easily affected by human activities: industrial activities and land use change have emitted 385 Gt C and 185 Gt C, respectively.

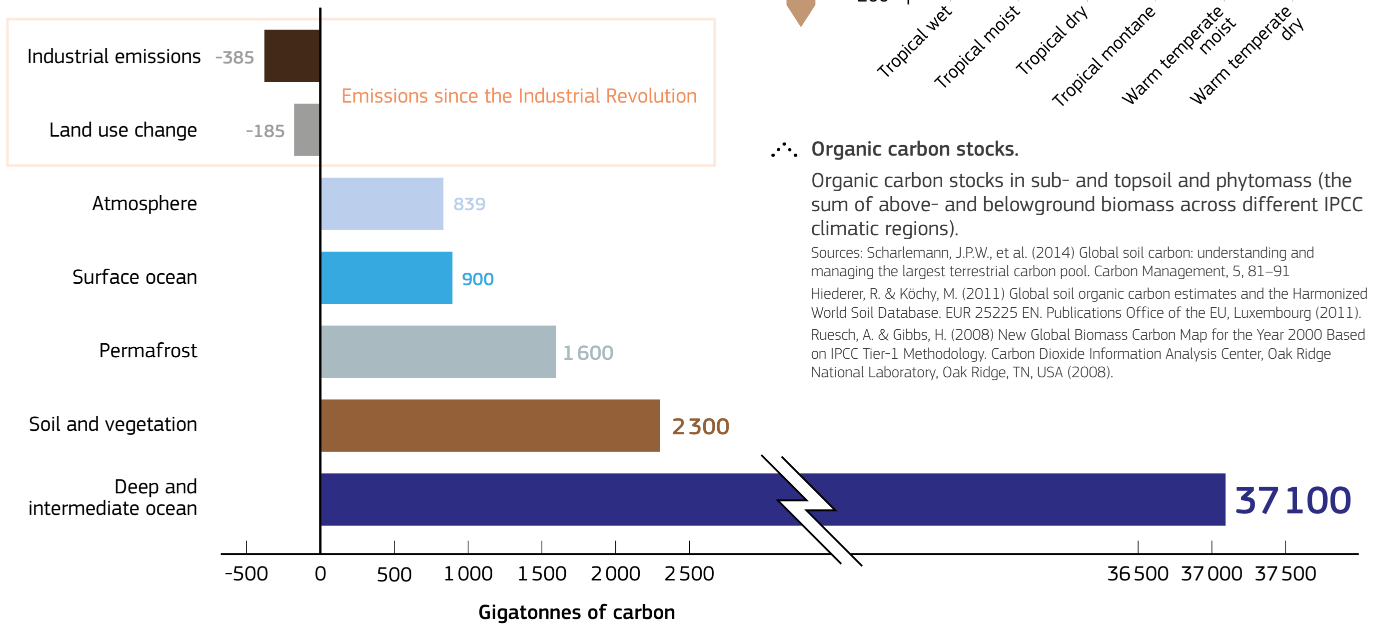
Forests store different amounts of carbon depending on the ecosystem types and climate zone. Tropical forests, for instance, make up two-thirds of all terrestrial biomass, whereas temperate and boreal forests contain just one-fifth of the carbon found in an equivalent area of tropical forest. In the tropics, wet, moist, and montane forests have much more carbon stored aboveground compared to belowground and in soil. In comparison, dry forests and grasslands store the majority of carbon in the soil[2].



Organic carbon stocks.

Organic carbon stocks in sub- and topsoil and phytomass (the sum of above- and belowground biomass across different IPCC climatic regions).

Sources: Scharlemann, J.P.W., et al. (2014) Global soil carbon: understanding and managing the largest terrestrial carbon pool. Carbon Management, 5, 81–91
Hiederer, R. & Köchy, M. (2011) Global soil organic carbon estimates and the Harmonized World Soil Database. EUR 25225 EN. Publications Office of the EU, Luxembourg (2011).
Ruesch, A. & Gibbs, H. (2008) New Global Biomass Carbon Map for the Year 2000 Based on IPCC Tier-1 Methodology. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, USA (2008).



The sizes of global carbon stocks, relative to the two main sources of emissions since the Industrial Revolution.

Main carbon stocks (excluding crust and mantle) and carbon emissions globally expressed as gigatons of carbon (Gt C).

Source: Janowiak, M. et al. (2017). Considering Forest and Grassland Carbon in Land Management. Gen. Tech. Rep. WO-95. Washington, D.C.: United States Department of Agriculture, Forest Service. 68 p.

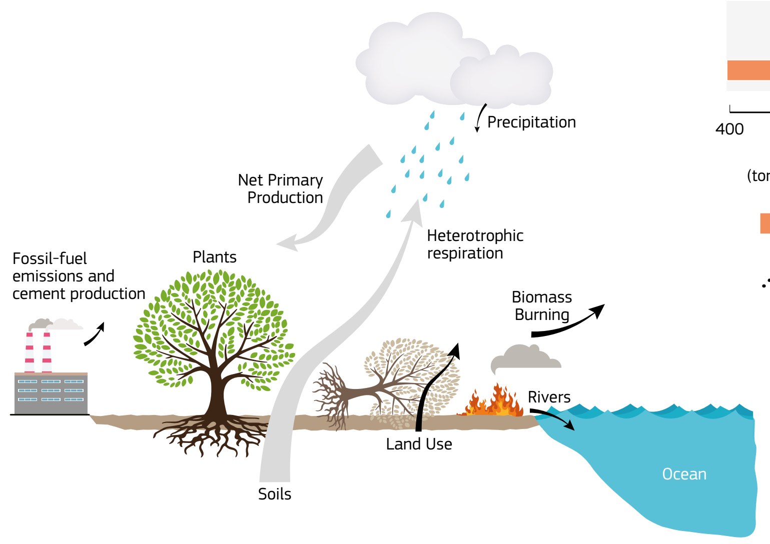
Africa is a key contributor to the global carbon cycle, but knowledge of the continent's exact contribution is full of uncertainties. A review of Africa's greenhouse gas budget[2] reported that Africa is probably a small carbon sink over annual timescales, removing approximately 0.61 (± 0.58) Gt C per year. However, other greenhouse gas emissions may turn Africa into a carbon source. There is considerable spatial variability in net carbon fluxes (i.e. the difference between carbon sinks and sources) in Africa, with southern Africa as the main source and central Africa as the main sink.

African tropical forests represents about a third of the world's tropical forest carbon sink (and 16 % of the global terrestrial carbon sink). A unique feature of Africa is that emissions from land-use change are significantly large (around 0.32 Gt C per year), even higher than emissions from fossil fuels. Fires are estimated to emit around 1.03 Gt C pear year, mainly from savannah and woodland burning (90 %). Globally, this represents more than half (52 %) of the global carbon emissions by fires, and more than a third of CH_4 emissions. The African continent is responsible for a large fraction (around 25 %) of the global carbon cycle's interannual variability.

The carbon cycle in Africa.

The African carbon cycle showing the importance of carbon storage in forests, and emissions related to soil degradation, land use changes and fires. Arrows are for illustrative purposes only and do not represent the magnitudes of different fluxes.

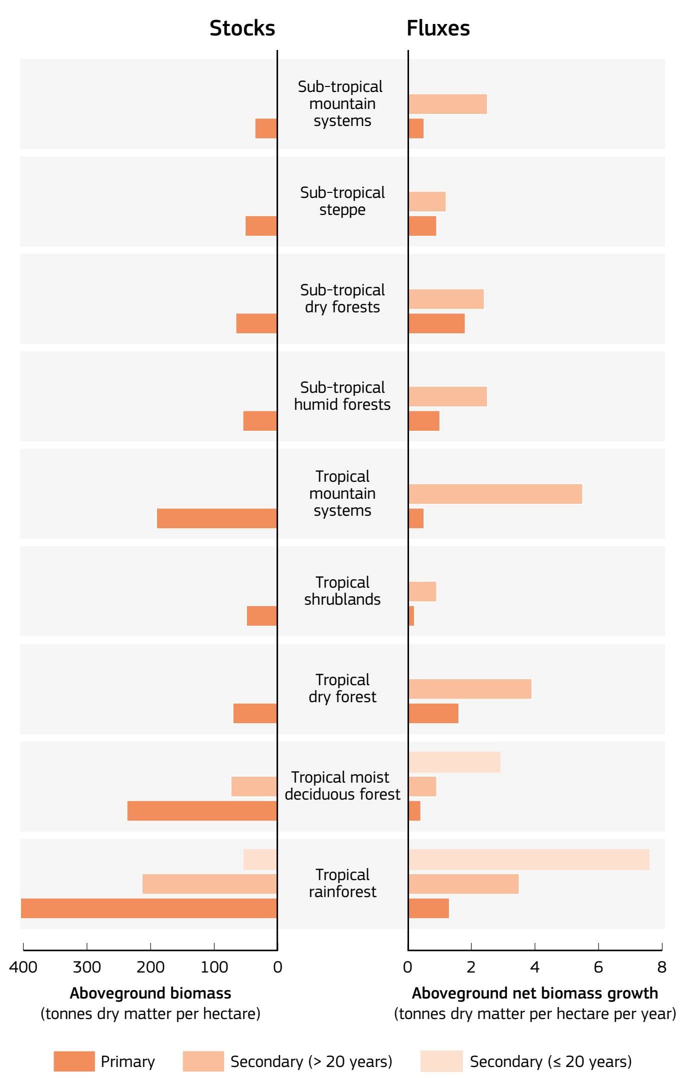
Sources: Modified from Williams, C.A., et al. (2007) Africa and the global carbon cycle. *Carbon Balance and Management*, 2, art. 3.



Carbon turnover within an ecosystem depends largely on climate, soil, vegetation type, and their interactions. Understanding these factors may be an indicator of which ecosystems might be most vulnerable to releasing CO_2 into the atmosphere. For example, biomass turnover in tropical forests is very fast due to high decomposition rates, so rather than accumulating in the soil, carbon is released into atmosphere after about 14 years on average. Turnover in tropical savannahs and grasslands is estimated to take 16 years on average, but in boreal forests turnover takes 53.3 years on average[3].

Natural ecological differences mean that there is not just one way in which nature can contribute to climate regulation. Some ecosystems are more effective at locking up carbon for the long-term, so preserving these carbon stocks ought to be a conservation priority. Other ecosystems might not store as much carbon, but are relatively better at drawing-down carbon dioxide from the atmosphere. For example, oceans are major carbon sinks for their capacity to absorb and store huge amounts of carbon, but the sequestration of carbon dioxide may lead to ocean acidification and threaten coral reefs. On land, forests have huge potential to store carbon,but the sequestration potential of grazing rangelands should not be underestimated[4].

The forests of Africa's Congo Basin are a large net carbon sink. Peatlands and tropical forests store high quantities of irrecoverable carbon: carbon reserves that are manageable, are vulnerable to disturbance, and could not be recovered by 2050 if lost today[5]. However, net forest greenhouse gases flux between 2001 and 2022 showed that sub-tropical woodlands generate higher net negative carbon fluxes (sequestration) than forests[6]. In tropical forests, deforestation along rivers, urban areas, and infrastructure led to positive net carbon fluxes. Combined, these results suggest that the strict protection of peatlands and tropical forests can secure long-term carbon storage, while sustainable management and restoration of woodlands and rangelands can achieve much higher carbon sequestration. Therefore, optimising the way African ecosystems contribute to climate regulation needs a nuanced, science-driven understanding of the interplay between ecology, biogeography, and climate.



Differences between stocks and fluxes for different African land classes.

Carbon stored as aboveground biomass is highest in primary forests and tends to be considerably less in secondary forest, open, or sub-tropical ecosystems. By contrast, net carbon fluxes are higher in young secondary ecosystems, regardless of being forested or not, suggesting that fast growing systems have the potential to sequester more carbon.

Sources: IPCC (2019) *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Calvo Buendia, E., et al. (eds). The Intergovernmental Panel on Climate Change, Switzerland.

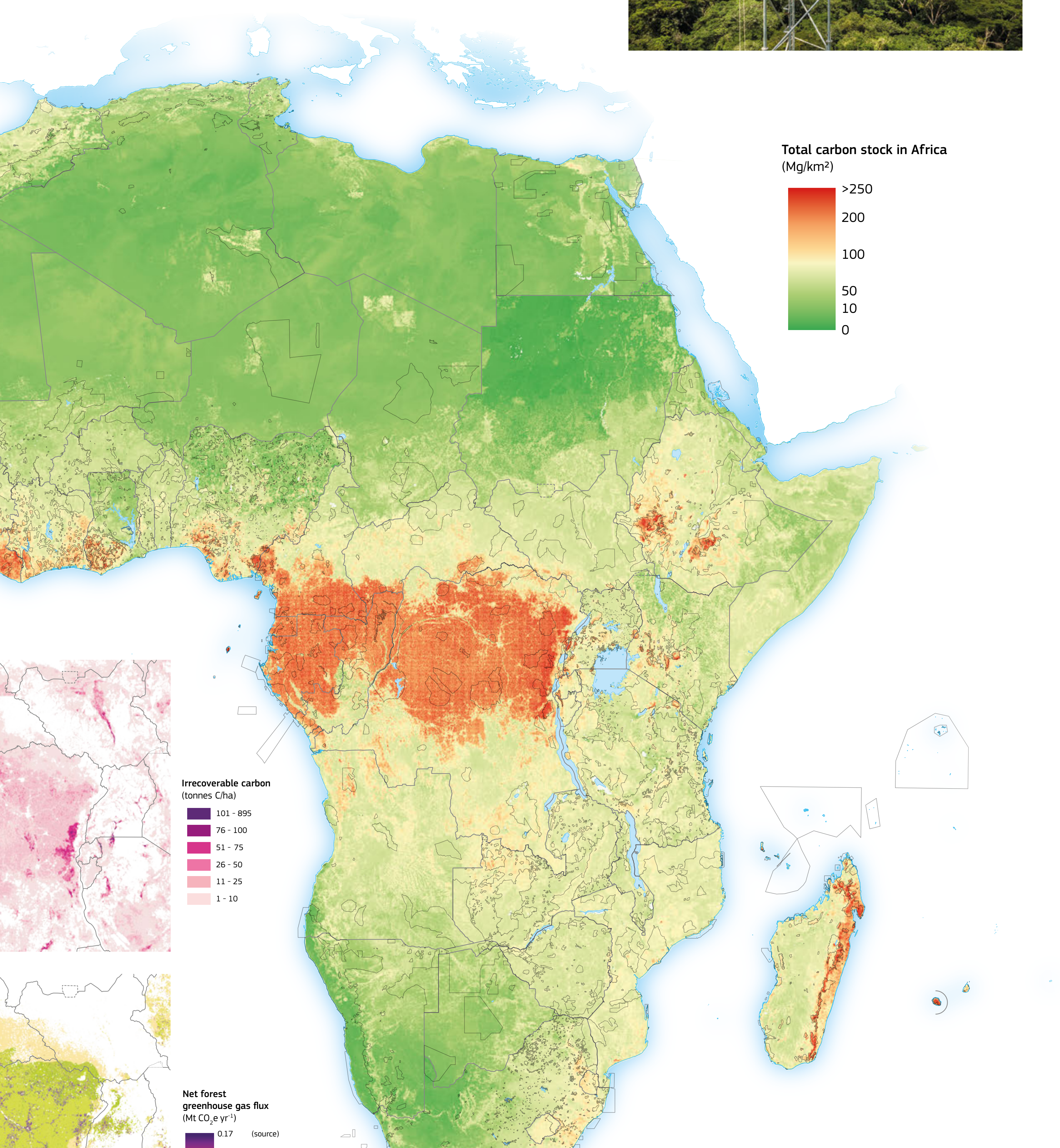
Total carbon stock in Africa.

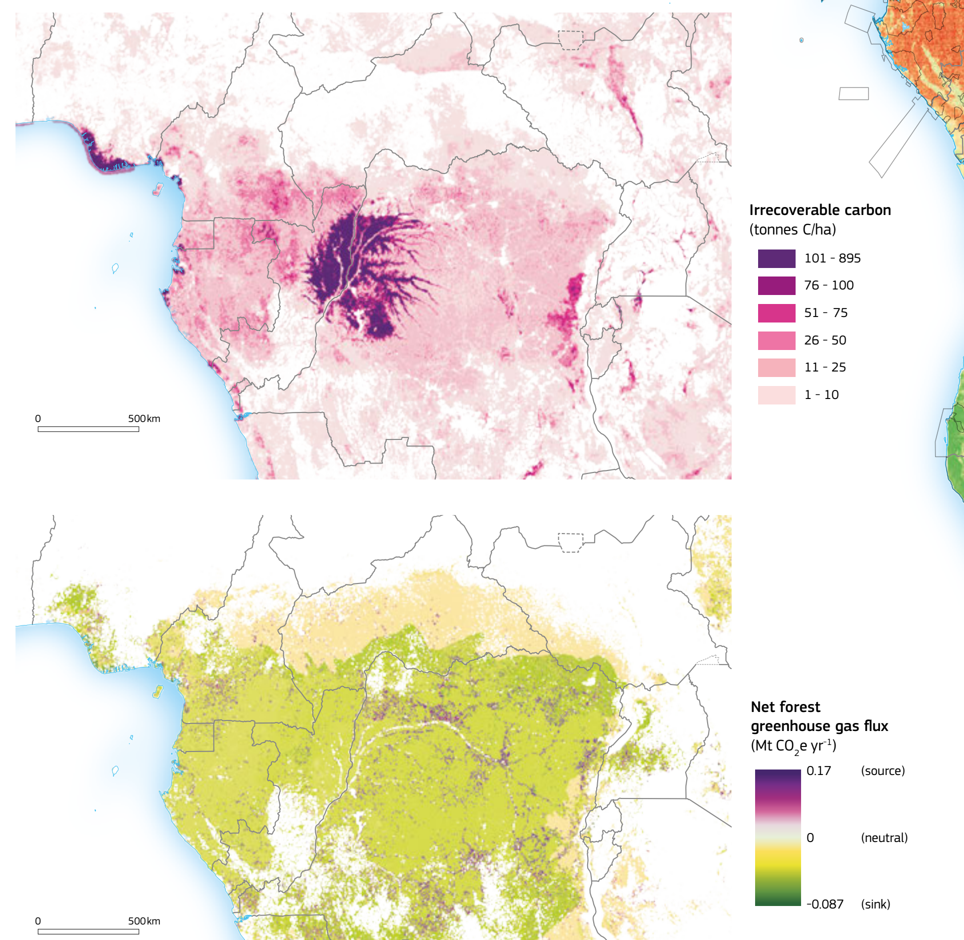
Here, the total carbon stock is the sum of carbon stored in aboveground biomass (e.g. stems, bark, and branches of living vegetation), belowground biomass (e.g. roots and underground stems), and soil (e.g. soil organic carbon), expressed in Mg/km².

Source: European Commission Joint Research Centre, combining data from:
FAO & ITPS (2018) Global Soil Organic Carbon Map (GSOC map) Version 1.2.0. Technical Report: http://www.fao.org/documents/card/en/c/I8891EN
Santoro, M., et al. (2018) GlobBiomass: global above-ground biomass and growing stock volume datasets.Available from: http://globbiomass.org/products/global-mapping.

A sensor tower to study greenhouse gas fluxes in the forests of Yangambi, Democratic Republic of the Congo.

Investing in research infrastructure is critical to understanding the role of African forest in regulating the global climate. This flux tower is fitted with sensors to monitor how changes to local and regional rainfall patterns affect how forests contribute to climate mitigation.





The distinction between carbon stocks and fluxes.

These maps of the Congo Basin show the differences between spatial patterns of irrecoverable carbon (Mg C ha^{-1}), which are carbon reserves that are manageable, are vulnerable to disturbance and could not be recovered by 2050 if lost today; and net forest greenhouse gas flux (Mt CO_2e yr^{-1}), the difference between carbon emissions and carbon removals.

Sources: (top) Noon, M.L., et al. (2021) Mapping the irrecoverable carbon in Earth's ecosystems. *Nature Sustainability*, 4, 37-46.
(bottom) Harris, N.L., et al. (2021) Global maps of twenty-first century forest carbon fluxes. *Nature Climate Change*, 11, 234-240.

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[6] Harris, N.L., et al. (2021) Global maps of twenty-first century forest carbon fluxes. *Nature Climate Change*, 11, 234-240.