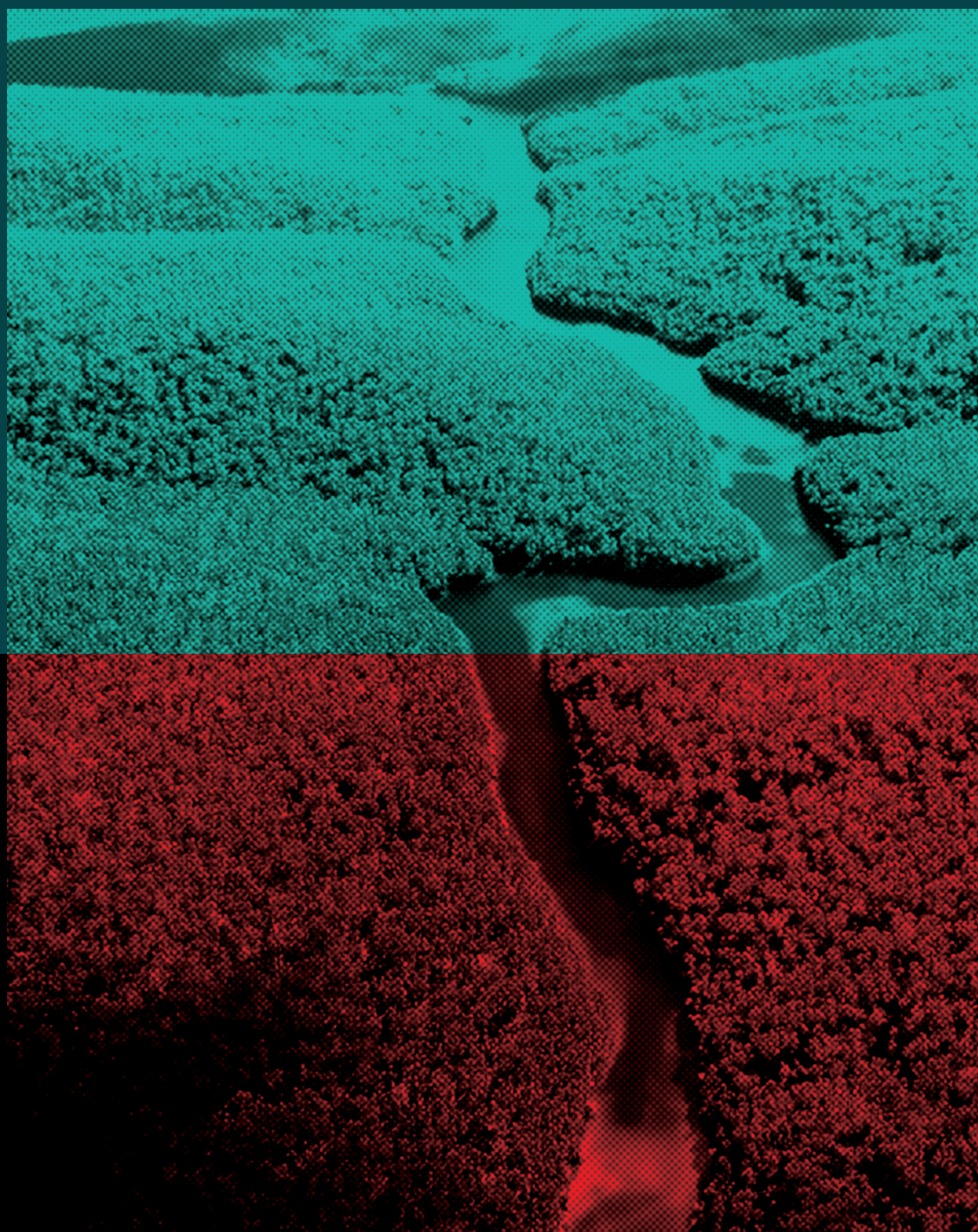


Science Panel for the Amazon Amazon Assessment Report 2021

EXECUTIVE SUMMARY



Science Panel for the Amazon

Executive Summary, Science Panel for the Amazon,
Amazon Assessment Report 2021
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About the Science Panel for the Amazon (SPA)

The Science Panel for the Amazon is an unprecedented initiative convened under the auspices of the United Nations Sustainable Development Solutions Network (SDSN). The SPA is composed of over 200 preeminent scientists and researchers from the eight Amazonian countries, French Guiana, and global partners. These experts came together to debate, analyze, and assemble the accumulated knowledge of the scientific community, Indigenous peoples, and other stakeholders that live and work in the Amazon.

The Panel is inspired by the Leticia Pact for the Amazon. This is a first-of-its-kind Report which provides a comprehensive, objective, open, transparent, systematic, and rigorous scientific assessment of the state of the Amazon's ecosystems, current trends, and their implications for the long-term well-being of the region, as well as opportunities and policy relevant options for conservation and sustainable development.

SUGGESTED CITATION

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TABLE OF CONTENTS

Acknowledgements	4
Introduction	5
Part 1: The Amazon as a Regional Entity of the Earth System	6
Part 2: Human Presence and Sociocultural Diversity in the Amazon	14
Part 3: Social-ecological Transformations: Changes in the Amazon	20
Part 4: The Solution Space: Finding Sustainable Pathways for the Amazon	34



Science Panel for the Amazon

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Introduction

This Executive Summary presents the key findings from the first Report (2021) of the Science Panel for the Amazon (SPA). The Report is organized in three parts: current state, threats, and solutions, highlighting the Amazon Basin's important biological, biogeochemical, and physical features, as well as its social, cultural, political-historical, and economic aspects. The Panel is comprised of more than 200 scientists from across the region as well as global partners, and mobilized a broader network of scientists, communities, practitioners, and managers through workshops and webinars. Engaging multiple voices in the co-design and generation of knowledge is a hallmark of the SPA. The integration of distinct visions of the future of the Amazon is critical to developing common principles and values based on respecting nature's limits.

Four major parts compose the structure of this summary:

- 1. The Amazon as a Regional Entity of the Earth System**
- 2. Human Presence and Sociocultural Diversity in the Amazon**
- 3. Social-ecological Transformations: Changes in the Amazon**
- 4. The Solution Space: Finding Sustainable Pathways for the Amazon**

The **Annex** presents supporting material about the geographical scope of the SPA, describing several distinct but overlapping hydrological, geological, biological, and political entities useful to distinguish the Amazon as a drainage basin, a sedimentary basin, a biodiversity province, and a political unit.

The scientific basis for each key message is found in the main Report, easily identified by the chapter references provided below, that presents a comprehensive understanding of the state of the Amazon's ecosystems, and their responses to unprecedented rates of change. The third part of the Report is devoted to solutions to halt or even reverse impacts, considering the social and biological diversity of Amazon, and the crucial role of Amazonian peoples, the opportunities for landscape-level conservation and restoration initiatives, and how a new bioeconomy based on healthy standing forests and flowing rivers can support regional transformation.

PART I

The Amazon as a Regional Entity of the Earth System



MESSAGE 1

The diversity of the region's climate, water flows, geomorphology, and soils led to the development of an equally diverse mosaic of terrestrial and aquatic ecosystems with extraordinary, unique, and irreplaceable biodiversity and complex biogeophysical interactions. These ecosystems were shaped by coupled dynamics between the high Andes and the lowland Amazon. The current configuration of the Amazon River network dates to the uplift of the Andes that accelerated about 10 million years ago, bringing the Amazon drainage basin to 0 – >6.0 km above sea level, and reflects complex geological and biological processes occurring over many millions of years.

BKG 1.1. The geology of the Amazon is distinct from Andes-influenced landscapes and soils, and is the result of interactions between plate tectonics, climate, dynamic topography, and sea level change, extending over many millions of years. Together, these factors created an exceptionally high geodiversity, from rock substrates to the hydrological, edaphic, and biophysical landscapes, playing an important role in the formation of Amazonian biodiversity. The modern Amazon Basin comprises a mixture of connected aquatic and terrestrial ecosystems, including extensive floodplains, large oxbow lakes, and *terra firme* forests with more than 50 different Andean-Amazonian ecosystems. Approximately 60% of Amazonian soils, especially those in the slowly eroding Eastern Amazon, are highly-weathered and nutrient-poor; however, these reflect the high diversity of the region as a whole, including 19 of the 32 World Reference Base Soil Groups, and exhibit a range of distinct physical, chemical, and biological properties. [CHO1](#), [CHO2](#), [CHO4](#)

BKG 1.2. The uplift of the Andes played a key role in forming the present climate, which in turn drove the formation of Andes-Amazon landscapes. Upon reaching a height of 2 km or more, the Andes blocked the westward flow of atmospheric moisture, increasing rainfall along its eastern flanks, increasing the volume of water discharged by the Amazon and Orinoco Rivers, and fundamentally changing South America's climatic regime. The origin of the transcontinental (Andes-to-Atlantic) Amazon River traces back 10 million years, while the modern drainage system was mostly in place by 4.5 million years ago, with large rearrangements among the major lowland tributaries continuing up to the present. Andes-Amazon connectivity is key for supplying water, sediments, nutrients, and minerals to the basin, and controlling the annual flood pulse upon which many aquatic and terrestrial species depend, as well as humans. Nutrient rich 'white water' rivers drain the Andes, while nutrient poor 'black water' and 'clear water' rivers drain lowlands and the highland plateaus. The flood pulse pushes river water into the floodplains and drives multiple physical, biological, and ecological processes, from sediment transport to fish migration and human livelihoods. [CHO1](#), [CHO2](#), [CHO4](#)

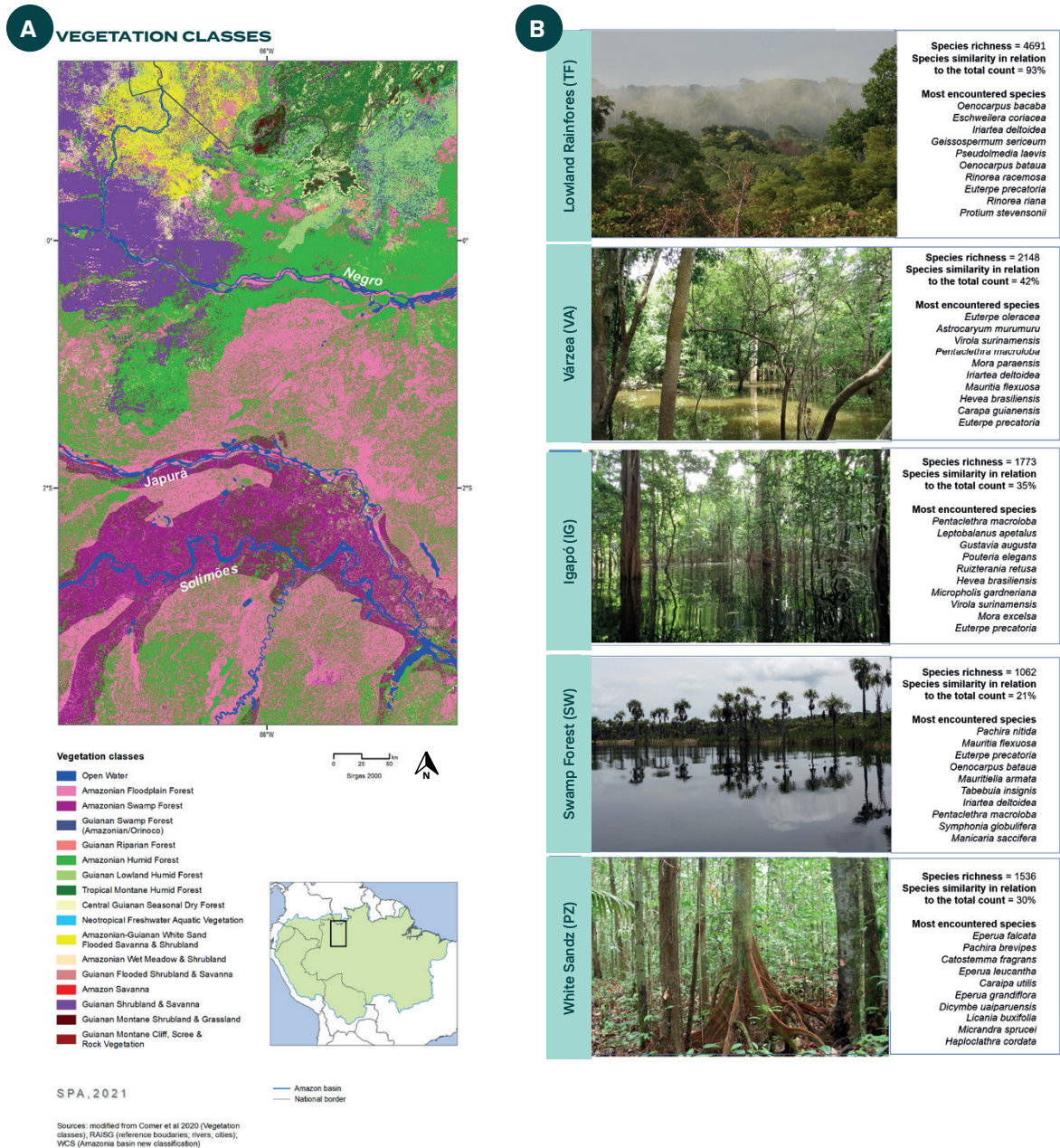


Figure 1. A. Key ecosystems are found in the Amazon lowland rainforest, such as Floodplain Forests, Amazon Savanna, White-Sand Savanna, and Seasonally Dry Forest. B. The ten most encountered tree species on ~2000 plots across Amazonia by forest type (IG – igapó, PZ – white sand forest; SW – swamp forest; TF – *terra firme* forest; VA – várzea forest). Top lines: total species encountered in plots in these forest systems and the percentage compared to the 5058 species in all 2000 plots (data: ter Steege et al 2015). Chapter 4.

ter Steege, H., N. C. A. Pitman, T. J. Killeen et al. 2015. Estimating the global conservation status of over 15,000 Amazonian tree species. *Science Advances* 1:e1500936.

MESSAGE 2

The Amazon is home to a remarkable share of known global biodiversity, including 18% of vascular plant species, 14% of birds, 9% of mammals, 8% of amphibians, and 18% of fishes that inhabit the Tropics. In parts of the Andes and Amazonian lowlands, a single gram of soil may contain more than 1,000 genetically-distinct fungi species. Ecological specialization and speciation in the Amazon occurred over millions of years of evolution under the influences of Andean uplifts, global climate cycles, and regional heterogeneity in climate, soils, nutrient availability, and biotic interactions. Although scientists describe new species in the Amazon at the extraordinary rate of one every other day, many groups are still poorly known. Moreover, our understanding of the ecology and geographic distributions for most species is still very limited.

BKG 2.1. Time and natural processes coupled with environmental heterogeneity, climate, and biotic interactions have produced an exceptional diversity of Amazonian species, genes, and ecological functions. The uplift of the Andes mountains, with an average elevation of about 4,000 meters, created both habitat and climate heterogeneity (including the humidification of Amazonian lowlands), stimulating numerous colonization, adaptation, and speciation events across many groups of organisms. Reorganization of the river network promoted by Andean uplift changed landscape connectivity, and hence dispersal, gene flow, and biotic diversification. Cycles of the global climate, with several glacial and interglacial periods over the past 2.6 million years, also profoundly affected terrestrial and aquatic Amazonian habitats, especially by changing precipitation patterns and sea levels. Although many modern groups of plants and animals show relatively constant rates of diversification over the past several million years, without abrupt variation during the Pleistocene (2.6 - 0.01 million years ago), these climate oscillations appear to have acted as a “species pump”, elevating species richness by repeatedly isolating and connecting habitats, fragmenting and merging populations, and increasing speciation in some groups while preserving other species from extinction. [CHO1](#), [CHO2](#), [CHO3](#)

BKG 2.2. Endemism is high in the Amazonian lowlands (below 250 m), with around 34% of mammals and 20% of birds not found elsewhere. The high level of endemism of Amazonian mammal species is due mainly to marsupials, rodents, and primates, which together comprise approximately 80% percent of all endemic animal species. The exceptional fish diversity represents approximately 13% of the world’s freshwater fishes, 58% of which are found nowhere else on Earth. The study of Amazonian biodiversity remains a challenge that demands long-term planning and effort. The scientific discovery of species, including naming new taxa, is critical for their protection against extinction, and the scientific assessment of their potential as new resources for multiple human uses. [CHO2](#), [CHO3](#)

BKG 2.3. The distribution of diversity is uneven across the Amazon, due to differences in soils, geology, climate gradients, and biological and ecological interactions. The highest tree diversity occurs in the northwestern and central Amazon, where single plots of one hectare may have over 300 tree species. The Precambrian Brazilian and Guiana shields present much lower diversity. However, high levels of endemism occur in the white-sand forests of the Guiana Shield (in the northwestern Amazon), expressing the unique nature of these ecological communities. Avian and mammalian faunas reach the greatest diversity in the western Amazon and the Andean foothills. At the same time, amphibians and fishes exhibit the highest local diversity in the western Amazonian lowlands, while geographic diversity is higher in the Andes, where species tend to have smaller ranges. **CHO2, CHO3, CHO4**

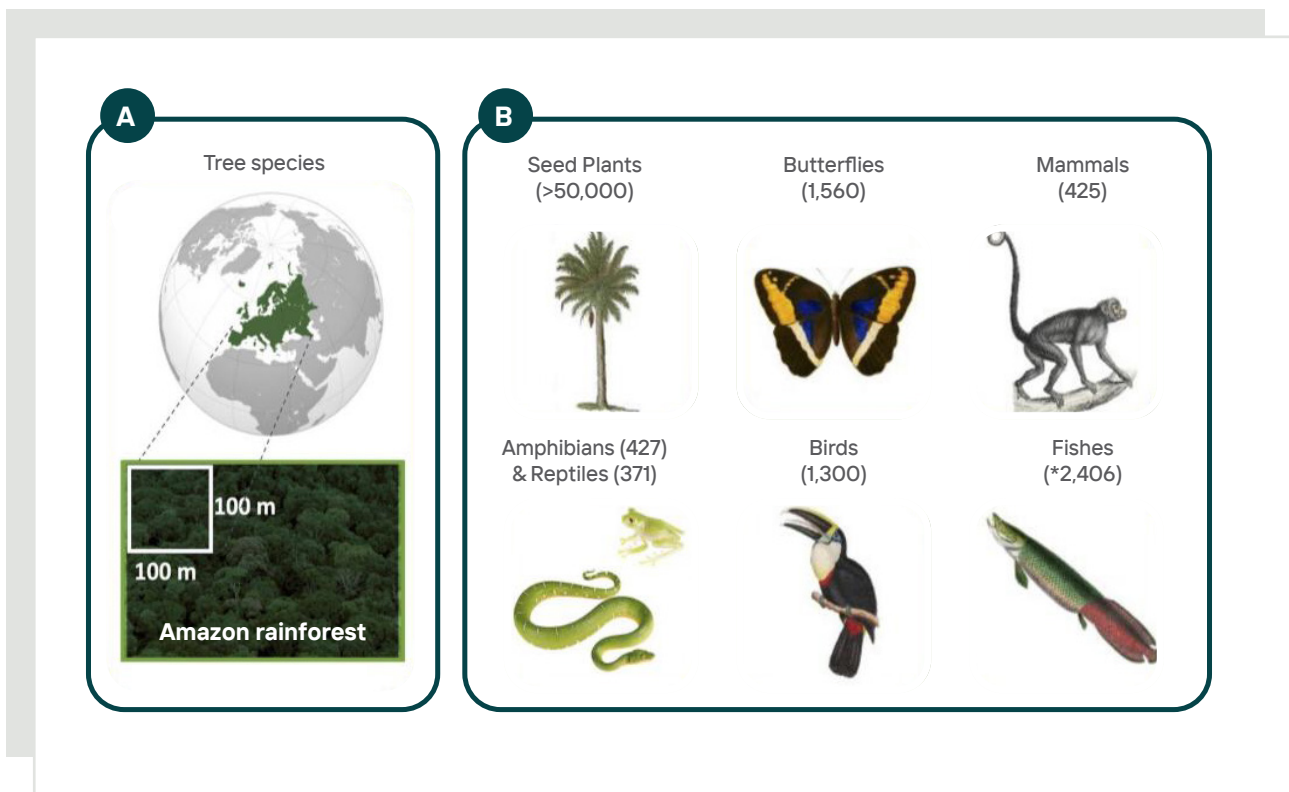


Figure 2. The Amazonian biodiversity in numbers. A. More tree species are found in 10,000 m² area of Amazon Rainforest than in all of Europe (Amaral *et al.* 2000, Gentry 1988). B. Estimated numbers of species of selected Amazonian lineages, including seed plants (Cardoso *et al.* 2017, ter Steege *et al.* 2016; image by Roberts 1839), butterflies (Vieira and Höfer 2021; image by Hewitson 1856), mammals (Mittermeier *et al.* 2003; image by Jardine *et al.* 1840), amphibians and reptiles (Mittermeier *et al.* 2003; image by Jose Vieira / Tropical Herping), birds (Mittermeier *et al.* 2003; image by Gould 1852), and fishes (Oberdorff *et al.*, 2019, Jézéquel *et al.* 2020; image by Castelnau, 1855). *Note that the numbers of plants and fish species corresponds to the whole basin. Although, most of fish (>95%) and plants are found in the lower basin (Ter Steege *et al.*, 2016; Albert *et al.* 2011, 2020; Dagosta and de Pinna 2020). Chapter 2, Chapter 3, Chapter 4.

Albert JS, Carvalho TP, Petry P, *et al.* 2011. Aquatic Biodiversity in the Amazon: Habitat Specialization and Geographic Isolation Promote Species Richness. *Animals* 1: 205–41. Albert JS, Tagliacollo VA, and Dagosta F. 2020. Diversification of Neotropical Freshwater Fishes. *Annu Rev Ecol Syst* 51: 27–53. Amaral, I. L., F. D. A. Matos, and J. Lima. 2000. Composição florística e parâmetros estruturais de um hectare de floresta densa de terra firme no Rio Uatumã, Amazônia, Brasil. *Acta Amazonica* 30:377–392. Cárdenas-López D, *et al.* 2016. The discovery of the Amazonian tree flora with an updated checklist of all known tree taxa. *Sci Rep* 6: 29549. Cardoso D, Särkinen T, Alexander S, *et al.* 2017. Amazon plant diversity revealed by a taxonomically verified species list. *Proc Natl Acad Sci* 114: 10695–700. Dagosta FCP and Pinna M de. 2017. Biogeography of Amazonian fishes: deconstructing river basins as biogeographic units. *Neotrop Ichthyol* 15. Gentry AH 1988. Tree species richness of upper Amazonian forests. *Proc. Natl. Acad. Sci.* 85: 156–159. Jézéquel C, Tedesco PA, Darwall W, *et al.* 2020. Freshwater fish diversity hotspots for conservation priorities in the Amazon Basin. *Conserv Biol* 34: 956–65. Mittermeier RA, Mittermeier CG, Brooks TM, *et al.* 2003. Wilderness and biodiversity conservation. *Proc Natl Acad Sci* 100: 10309–13. Oberdorff T, Dias MS, Jézéquel C, *et al.* 2019. Unexpected fish diversity gradients in the Amazon basin. *Sci Adv* 5: eaav8681. Ter Steege H, Pitman NCA, Phillips OL, *et al.* 2006. Continental-scale patterns of canopy tree composition and function across Amazonia. *Nature* 443: 444–447. Ter Steege H, Vaessen RW, taxonomically verified species list. *Proc Natl Acad Sci* 114: 10695–700. Vieira R and Höfer H. 2021. Butterflies of the Amazon. <https://www.amazonian-butterflies.net>.

MESSAGE 3

The Amazon River Basin is one of the most critical elements of the Earth's climate system, due to its tropical location, bounded to the west by the Andes, and its immense spatial extent. The forests act like a giant "air-conditioner", lowering land surface temperatures, and generating rainfall. It exerts a strong influence on the atmosphere and circulation patterns, both within and outside the tropics. Up to 50% of the precipitation that falls within the basin is regionally recycled, sustaining a high flow of moisture inland from the oceans and supplying the largest river discharge on Earth, 16 to 22% of the world's total river input to the oceans.

BKG 3.1. The Amazon is a critical source of energy to the atmosphere. The Amazon Forest removes latent heat from the surface by evapotranspiration and releases it to the atmosphere through condensation and cloud formation. The abundant rainfall in the Amazon basin, averaging around 2,200 mm/yr and reaching 6,000-7,000 mm/yr at the base of the Andes, is a consequence of intense radiative heating, low-level convergence of oceanic water vapor, and permanent injection of water vapor into the atmosphere by the forest itself, aided by the mechanical uplifting of air by the Andes and the existence of aerial rivers. Annually, an estimate 72% of the water vapor that enters the atmospheric column is of oceanic origin and 28% is evaporated locally; thus, the forest and evapotranspiration play a significant role on the climate. At the base of the Andes precipitation recycling reaches over 50%. Amazon forests also sustain the hydrological cycle by emitting volatile organic compounds (VOCs, such as terpenes) that become cloud condensation nuclei and lead to the formation of rain droplets. [CHO5](#), [CHO6](#), [CHO7](#)

BKG 3.2. Amazon trees act as a biotic pump, capturing water from soil and throwing it into the atmosphere through evapotranspiration. Characteristics like deep roots (up 18 m deep in some areas), plant hydraulic redistribution, and synchronization of new leaf emergence with the dry season, lead to higher rates of evapotranspiration during the dry season and suggest that Amazonian forests are resilient to episodic extreme droughts. These combined mechanisms lead to a rainy climate on average and an early start and late end of the rainy season, playing an important role, as for instance, in southern Amazon, through an input of water vapor during the dry-to-wet season transition, which can bring major economic and social impacts in the region. [CHO5](#), [CHO7](#)

BKG 3.3. The Amazon region is an important source of water and moisture for ecosystems beyond the basin itself (e.g., glaciers, *páramos*, cloud forests, and rainforests) and human settlements over the Andes mountains and the eastern Andean foothills. A significant portion of moisture flows southward, towards central and southern South America, interacting with the Chaco Low, to the La Plata River basin, the Pantanal, and the agricultural lands of west-central Brazil. This water vapor

transport happens in relatively narrow spaces of the atmosphere (“aerial rivers” of about 1 km wide) via the South American Low-Level Jet east of the Andes. Over the La Plata River basin, and possibly over the Pantanal and Andean regions, the Amazon is the second-highest continental contributor for annual mean precipitation. This system also transports smoke and aerosols from biomass burning in the Amazon to adjacent regions, exacerbating atmospheric pollution affecting urban areas across the continent. **CHO5, CHO7, CH21**

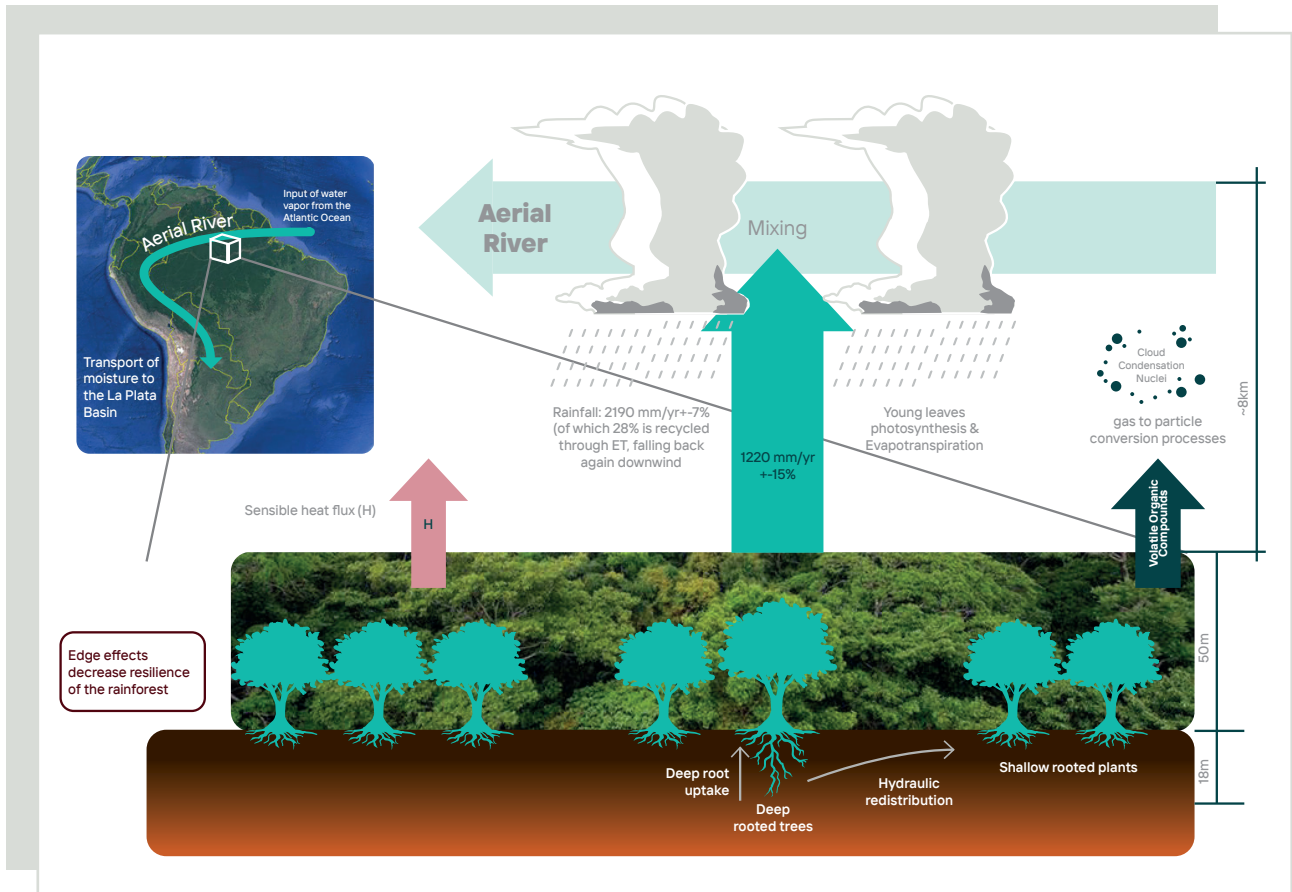


Figure 3. Main biogeophysical features and processes of the biosphere-atmosphere interactions in the Amazon: Deep rooting trees, hydraulic redistribution, and synchronization between leaf emergence with solar radiation maximum maintain high rates of evapotranspiration into the atmosphere through the year and in dry years. Permanent injection of water vapor by vegetation increases rainfall inside the Amazon, and the excess moisture is transported to the La Plata Basin, increasing precipitation there as well. Chapter 5, Chapter 7.

MESSAGE 4

The Amazon basin represents a large component of the global carbon cycle, accounting for about 16% of terrestrial productivity and 150-200 billion tons of carbon stored in soils and vegetation. Undisturbed regions of the Amazon lowland forest are a net carbon sink (about -0.22 ± 0.30 Gt C/yr), though this may be weakening over time. High rates of productivity, even where soils have low nutrients, are related to efficient biodiversity-mediated mechanisms to recycle nutrients. Amazonian wetlands release 6-8% of global methane emissions.

BKG 4.1. Production of woody biomass (the longest-lived plant tissue, and an important carbon stock) accounts for 8-13% of the photosynthetic carbon uptake. The ability of ecosystems to capture, process, and store carbon and other nutrients is determined by climatic, edaphic, hydrological, and biological factors. Rates of net primary productivity (NPP) and woody biomass production are higher in the soils of the western Amazon which are younger, more humid, and higher in phosphorus. Mature Amazonian ecosystems store large amounts of carbon both above and below ground (150-200 Gt C). Some wetlands can contribute to carbon storage by accumulating peat deposits, though most of the carbon accumulated is recycled annually. Presumably, through much of the time since the last glaciation, the basin-wide uptake of carbon by photosynthesis roughly balanced losses through respiration and decomposition, with some net carbon export by rivers. Currently, the net carbon loss in areas of deforestation is matched by carbon gains in areas of reforestation and uptake in mature forests. This uptake has been estimated at around -0.22 Gt C/yr \pm 0.30 Gt C/yr; this net sink is globally important but as yet poorly understood. **CHO6, CH19, CROSS-BOX AMAZON CARBON BUDGET**

BKG 4.2. Multiple interactions between biogeochemical cycles can affect the Amazon's carbon cycle, while co-limitation by nitrogen and phosphorus is an important constraint to plant productivity. Phosphorus limitation may result in a reduction in the NPP response to the increase of CO₂ in the atmosphere (CO₂ fertilization) by up to 50% in the Amazon. Inputs of nitrogen to Amazonian ecosystems are derived largely from biological nitrogen fixation by microorganisms. The high productivity of the Amazon Forest despite the low availability of phosphorus is facilitated by very tight recycling within the forest system. Around half of leaf phosphorus is either resorbed prior to leaf senescence or rapidly captured by fungal hyphae soon after litter fall or plant death. **CHO6**

BKG 4.3. The Amazon is a globally important natural source of methane (37-48 million tons CH₄/yr). The overall CH₄ budget in the Amazon includes multiple sinks (e.g., forests with well-drained soils) and sources (e.g., bromeliads, termite mounds, wetlands) whose contributions are sensitive to feedback from drought conditions. It remains poorly understood how hydrological changes will affect methane fluxes. Well-drained soils in upland forests are often a net CH₄ sink (1-3 Mt CH₄/yr), although under localized anoxic conditions CH₄ can be released. Fluxes of methane from all aquatic environments within the catchments of the Amazon and Tocantins River systems are estimated to be approximately 51 Mt CH₄/yr. High rates of primary production by plants and algae in aquatic environments, considerable sedimentation in lakes and reservoirs, and large amounts of carbon dioxide and methane emitted from rivers, lakes, and wetlands all lead to disproportionately large fluxes relative to the area of aquatic systems. **CHO4, CHO6, CROSS-BOX AMAZON CARBON BUDGET**

PART 2

Human Presence and Sociocultural Diversity in the Amazon



MESSAGE 5

The Amazon is also home to a notable diversity of sociocultural groups. Human occupation of the Amazon started at least 12,000 years ago and the Amazon was a center of cultural and technological innovation in the past. Currently, the Pan-Amazon is home to around 47 million people, including Indigenous people (nearly 2.2 million), Afro-descendent communities (*Maroons, Quilombolas*), and extractivists of mixed descent (*mestizos, caboclos, ribeirinhos*). Indigenous peoples and local communities (IPLCs) play a critical role in the generation, conservation, and management of Amazonian agricultural and biological diversity, as well as ecosystems. Indigenous peoples are distributed among more than 410 groups, around 80 of which remain in voluntary isolation. About 300 Indigenous languages are spoken in the region, and the southwestern Amazon harbors one of the greatest concentrations of linguistic isolates on the planet. When European colonizers arrived in the region (16th century), the Indigenous population was estimated to be 8 to 10 million people, speaking more than 1,000 distinct languages. In just 200 years following colonization, Indigenous populations had declined by as much as 90%, due to slavery, campaigns of extermination, and exposure to diseases brought from Europe and Africa. Vulnerability to diseases still affects present-day Indigenous peoples and local communities.

BKG 5.1. When humans first arrived in the region in the Late Pleistocene, the climate was about 5°C cooler and, in some places, up to 50% drier than today. It gradually warmed with the onset of the Holocene (11,700 BP), leading to forest expansion. At the same time, human populations began increasing across the continent. Cultural diversity among these early settlers was expressed in different rock art styles – the earliest in the Americas – and different styles of stone tools. Starting 7,000 years ago, four distinct areas of the Amazon independently developed ceramic technology, in one case the earliest use of ceramics in the Americas. The Amazon was a cradle for cultural innovation within the deep history of the Americas. Such innovations forged and promoted local regional identities, past and present, continuously playing a fundamental part in building connections between societies, species, ecosystems, and spiritual worlds. [CHO8](#)

BKG 5.2. In the Amazon, variability of material culture and settlement patterns match that of its Indigenous languages. Languages and livelihoods in the Amazon are major ways to express biocultural connections which have co-evolved over time and function as linked social-ecological systems. Co-evolution between human occupation and biodiverse ecosystems was likely a driver for the emergence of cultural diversity among early settlers, establishing a pattern that prevailed throughout the Holocene. This pattern can be seen today in the large diversity of surviving languages; around 50 of the world's 125 isolated languages are found in Amazon. With over 10 language isolates at the headwaters of the Guaporé and Mamoré rivers, a region the size of Germany, the southwestern Amazon harbors one of the greatest incidences of linguistic isolates on the planet. Comparative linguistics can teach us not only about where people lived, but also about aspects of how they lived. After 7,000 years, languages tend to have changed so much that it is not possible to establish any family relationship. This might explain the existence of many language isolates, though an alternative explanation is that all other languages of the same family have died out. [CHO8](#), [CH10](#), [CH12](#)

BKG 5.3. Since the era of European conquest, the extraction of natural resources has been accompanied by the subjugation and exploitation, geographic displacement, and development of multiple forms of domination and extermination of Indigenous peoples and local communities. The 16th-18th centuries forged some persistent myths about the Amazon, seen as a space of wealth (metals, medicines), but also as marginal, distant, dangerous, and sometimes empty (as a result of depopulation). Colonial notions such as those based on the "civilization"/"savagery" duality have strongly influenced political and social relations with the political-administrative centers of kingdoms and republics, and between Indigenous and non-Indigenous peoples. These kinds of dichotomies often appear in the region's development policies and proposals. The construction of "borders", "limits", and "frontiers" have also been recurrent in the territory: between the European kingdoms and the inheriting States of the Spanish, Portuguese, Dutch, English or French colonies; between the mountains and the lowlands; or among Indigenous peoples. These borders often ignore past and present dynamics of intense exchange, such as those between Amazonian territories and the coasts and high Andes. [CHO9](#)

BKG 5.4. Contact between Indigenous peoples and non-Indigenous populations or their agents led to catastrophic declines in Indigenous populations, especially during the first century of European conquest. Diseases originating from domesticated European farm animals had a great impact on Indigenous depopulation. Demographic contraction contributed to perpetuating the ideas of Amazonian emptiness and the rupture between the Amazon and the Andes. By the 16th century, there were roughly 8 to 10 million people living in either small, semi-permanent settlements, or large permanent villages of over 50 hectares. The relationship between Indigenous peoples and European conquerors and colonizers was usually violent and defined by tension; attempts at military and religious domination often met with resistance. The Amazonian peoples subjected to living in religious villages underwent ethnogenesis that gave rise to new identities, combining both traditional and missionary elements. The introduction of technologies such as iron tools created both new relations and tensions among Indigenous peoples, and between them and the colonists. Several of today's Amazonian cities, such as Belém and Santarém, are located in areas previously occupied by Indigenous peoples, while others were built in new places. The Indigenous population of the Amazon today is just a small fraction (around 10%-20%) of what it was on the eve of the European invasion.

CHO8, CHO9

BKG 5.5. Together, Indigenous peoples and local communities play a critical role in the sustainable use and conservation of Amazonian biodiversity, holding long-term, experiential knowledge (defined as Indigenous and local knowledge, or ILK) of agricultural, aquatic, and agroforestry systems. Africans brought to the Americas as slaves and their descendants brought their own agricultural traditions, and many agricultural techniques adopting diversified crops and agrobiodiversity. Product markets have opened bridges for many Afro communities to establish urban livelihoods, highlighting urban rural connections. Despite the important role played by IPLCs in preserving Amazonian biocultural diversity, economies, and conservation, these human groups have been historically displaced from their territories, and often overlooked in scientific research, recognition of rights, and social and environmental policies. CHO8, CH10, CH11, CH13, CH14, CH15, CH16

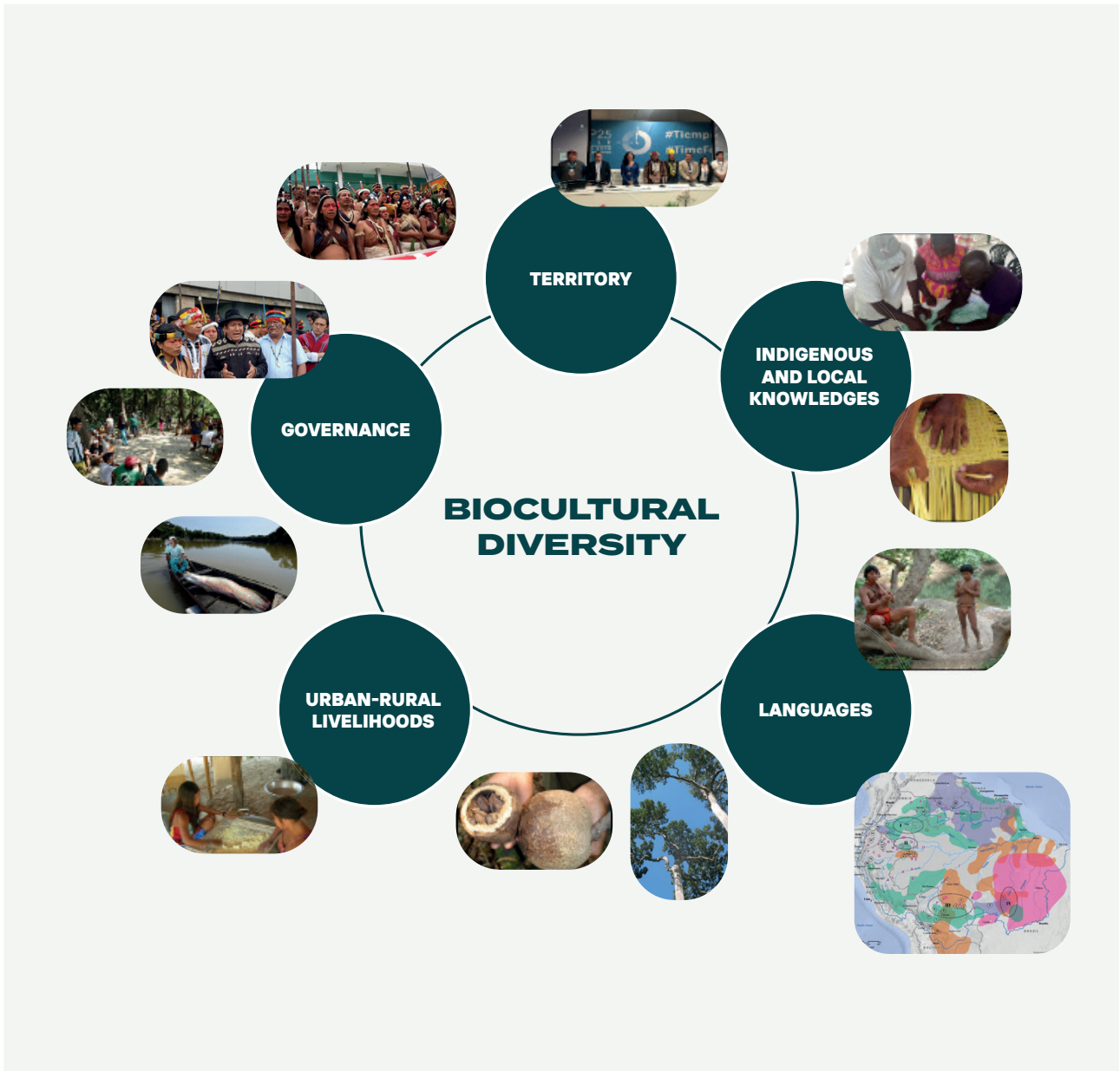


Figure 4. The interconnectedness between biocultural diversity elements and sustainability: territory and rights, governance and self-determination, linguistic diversity, knowledge, and livelihoods. The concept of biocultural diversity considers the diversity of life in its human-environmental dimensions, that includes biological, sociocultural and linguistic diversity, which are interconnected and have evolved as social-ecological systems. Guaranteeing territorial rights and self-determination of Indigenous peoples and local communities is among the most important strategies for protecting biodiversity and biocultural landscapes in the Amazon, with significant implications for regional and global climate stability, as well as water and food security for all. Chapter 10. Photo credits, clockwise from the top ("territory"): Coordinadora de las Organizaciones Indígenas de la Cuenca Amazónica (COICA), Amazon Conservation Team, Simone Athayde, Stanford Zent, Simone Athayde, Glenn Shepard, Glenn Shepard, Simone Athayde, Adriano Gambarini, Adriano Gambarini, COICA. Chapter 10

MESSAGE 6

The Amazon is one of the few independent centers of plant domestication in the world, constituting an area of agricultural innovation. Ancient Amazonians played a key role in configuring forest and urban landscapes. Agricultural production modes existing before the arrival of Europeans included a legacy of agrobiodiversity and domesticated plants, mostly trees and other perennials, impacting both plant distribution in natural ecosystems, particularly Amazonian forests, and human well-being. Indigenous crops such as cocoa and manioc were exported by colonizers, influencing human nutrition across the globe.

BKG 6.1. Indigenous peoples' legacy of transforming nature in the Amazon over millennia can make it difficult to disentangle some aspects of its natural history from its Indigenous history and testifies to the inextricable link between cultural and biological diversity (or biocultural diversity) in the Amazon. By culturally modifying the environments in which they lived and dwelled, Indigenous peoples and local communities have domesticated landscapes, increasing food availability near their homes through practices including the removal of unwanted plants, protecting useful trees throughout their development, attracting animal dispersers of seeds, directly dispersing seeds themselves, selecting specific phenotypes, managing fire, cultivating valuable plants, and increasing soil fertility and structure by creating anthropogenic soils and earthworks. Such landscape changes became more drastic from 2,500 years ago onwards, with the widespread production of anthropic soils (*terras pretas*), mound building, and the construction of earthworks such as ditches, wells, channels, and roads. As a result, human management and selection practices had a meaningful role in plant distribution and abundance, local environmental conditions, and biological interactions around human settlements. **CH08, CH10**

BKG 6.2. More than a hundred plant species native to the Amazon – mostly trees and other perennial species – were domesticated to some degree by pre-Columbian peoples. Such practices transformed the Amazon, one of the few independent centers of plant domestication in the world, and made it a cradle for agrobiodiversity production, embedded in systems of knowledge still kept by Indigenous and other socio-cultural groups to the present day. Genetic evidence has long suggested that the southwestern Amazon, including Bolivia and Brazil, was a hotspot of plant domestication since it is there that the closest wild relatives of manioc (*Manihot esculenta*), peanut (*Arachis hypogea*), squash (*Cucurbita maxima*), chili pepper (*Capsicum baccatum*), annatto (*Bixa orellana*), peach palm (*Bactris gasipaes*), and cocoa (*Theobroma cacao*) are found. Before European invasion, Indigenous peoples who inhabited the so-called "piedmont" or foothills were fundamental in facilitating connection between the Andes and the Amazon. These "hinge" peoples brought together knowledge, myths, and trade in goods such as pepper, coca, potatoes, and corn. The multi-cropping systems of many communities from the African tropical belt further transformed the rainforest into a food forest, incorporating

Amerindian staples such as corn, sweet potatoes, cassava, and peanuts. Africans domesticated plants and have traditionally been pastoralists, introducing knowledge about forage plants and animals crucial in adapting species for agriculture and livestock in the Americas. Women have played a prominent role in promoting, managing, and protecting agrobiodiversity, significantly contributing to food security and sovereignty among Amazonian sociocultural populations. These plant cultivation practices are a source for agrobiodiversity production, are embedded in systems of knowledge, and kept by Indigenous, Afro-descendant, and other local communities of the Amazon. [CHO8](#), [CH10](#), [CH13](#)

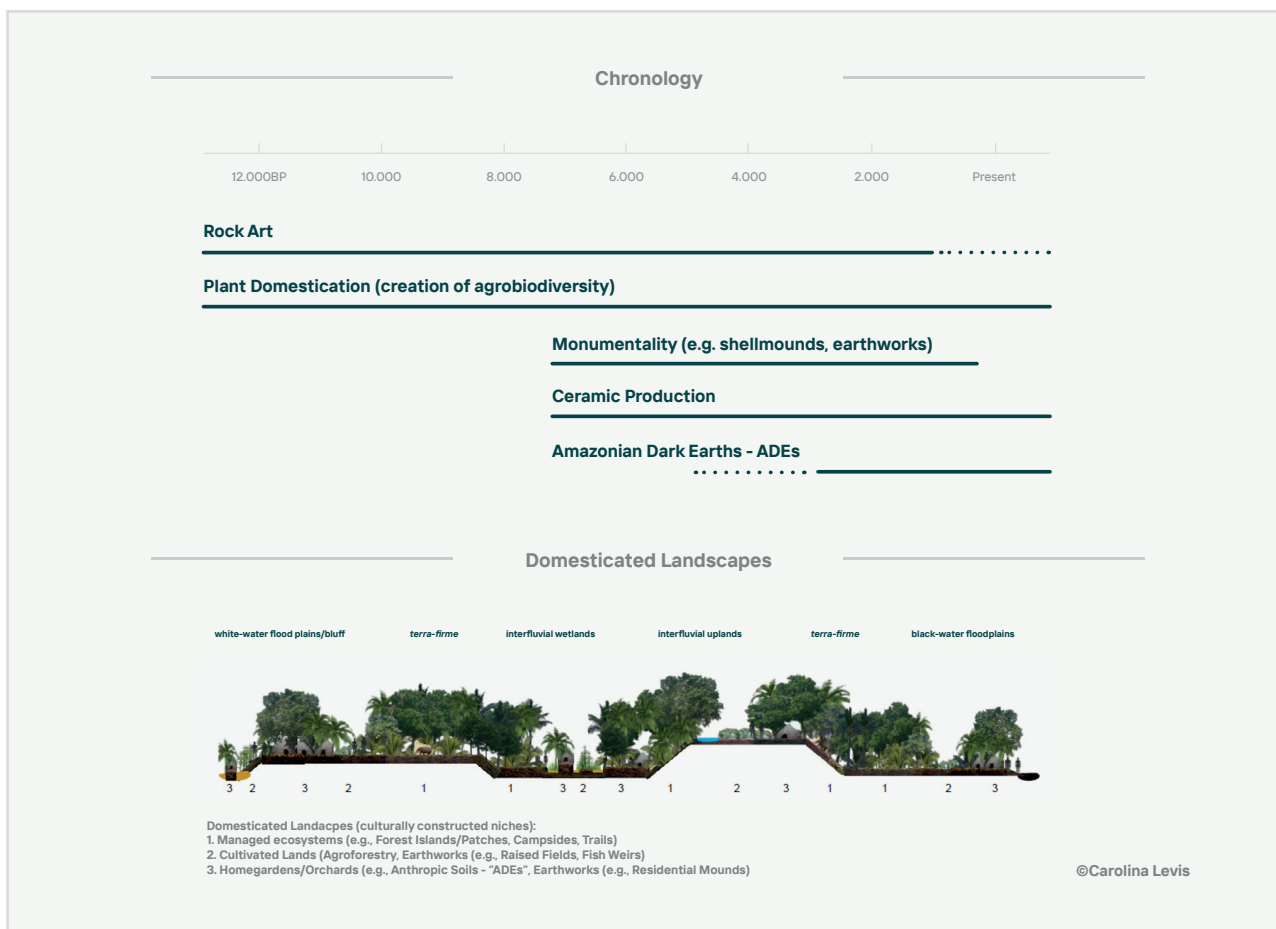
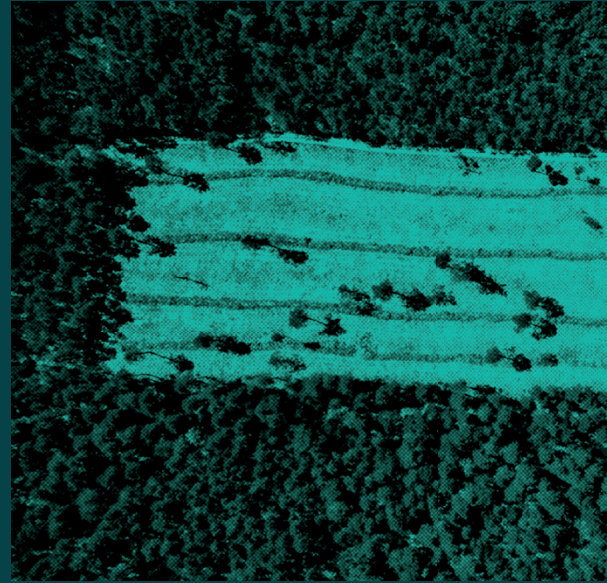


Figure 5. Schematic representation of the landscape transformations associated with the Indigenous occupation history of the Amazon. Proximity to residential sites increases management practices and plant domestication intensifies. Chapter 8.

PART 3

Social-ecological Transformations: Changes in the Amazon



MESSAGE 7

Over the past two centuries, Amazonian resources (oil, minerals, and biodiversity) have been extracted and used intensively due to the colonization process and massive national agricultural expansion programs driven by both domestic and international economic demands. The exploitation of raw materials is cyclical, with rising (boom) and falling (bust) periods, which shaped diverse social, economic, and spatial structures, sometimes to the detriment of previous territorial dynamics. In the post-World War II period, the governments of Amazonian countries dramatically increased their engagement in the Amazon through extensive settlement projects (both formal and informal), agrarian reform programs, infrastructure development, urbanization, incentivized export sectors, and the expansion of mining, energy exploitation (oil, gas, coal, and hydro), and cultivation of livestock and crops. Resource-based development meant that Amazonian countries moved to the top tiers in global exports of beef, iron, gold, timber, cocoa, and soy. These transformations occurred in the context of highly unequal societies, with substantial parts of the Indigenous population not even having citizenship, or the exclusion of local communities from civil society or land rights, inequities that influence the socioeconomic dynamics of the region to this day.

BKG 7.1. The exploitation of products such as Cinchona and rubber, starting in the 19th century, led to the opening of waterways, roads, cities, settlements, and collection and distribution centers, as well as population movements. In the early 1960s, the predominant perception among national governments was that Amazonian territories were empty, “unused” spaces, with formidable reserves of natural resources (e.g., minerals, oil, hydroelectric energy, wood, agriculture, and plants for pharmaceutical and cosmetic uses), and with their sovereignty at risk, which initiated an intensification of the process of exploration and occupation of the region. In this time, internal and external populations moved into Amazonian regions and deforestation became a central means of claiming land, whether for legal or illegal tenure, production, and land speculation. [CH11](#), [CH14](#)

BKG 7.2. In the late 1970s, a new global development paradigm emerged based on neoliberal concepts, conducting Latin America towards an export-oriented and market-friendly model. The Amazon underwent a deep structural shift from traditional to wage-based, market-oriented social relations accompanied by massive transfers of public lands into private holdings, and more generally, from a rural population into a very precarious urban one. Today, the Amazon is a significant provider of raw materials, including iron ore, soybeans and beef (Brazil), oil (Peru, Ecuador, Colombia), gas (Bolivia, Peru), gold (Brazil, Peru, Venezuela, Suriname), timber (Brazil, Colombia, Peru), and hydroelectric power (all Amazonian countries). A complex process of infrastructure expansion, migration, and urbanization took different forms, without substantially improving living conditions and at the expense of deforestation and the degradation of aquatic and terrestrial ecosystems. [CH14](#), [CH15](#), [CH17](#), [CH18](#)

BKG 7.3. Intense human intervention in the Amazon threatens the rainforest, aquatic ecosystems, and the survival of IPLCs. The rapid expansion of agricultural and extractive activities, mainly geared towards export but also to supply domestic markets, drove significant deforestation and environmental degradation without substantially improving living conditions. The unsustainable extraction model has accelerated deforestation, environmental degradation, and biodiversity loss. This model has been stronger than conservation in all cases, although an important portion of Amazonian land is protected or covered by recognized Indigenous territories and other protected areas. Additionally, the Amazon exemplifies social and economic inequality. For instance, in examining poverty data (GDP and HDI) for Brazil and Ecuador, Amazonian regions are the most deprived relative to other areas of both countries. [CH14](#), [CH15](#), [CH17](#), [CH18](#)

MESSAGE 8

The Amazon’s population overall is more than 60% urban. As a result, Amazonian livelihoods are increasingly a complex mixture of rural and urban activities. In addition, national and regional policies aimed at development, financial support, and infrastructure favor large-scale agribusiness, generating significant structural changes among Amazonian smallholders and increasing urban migration. This reality contradicts images of the Amazon as predominantly rural and is reflected in the limited attention paid to the region’s explosive urbanization and built environments.

BKG 8.1. The Amazon's population is highly diverse, with people living in ranches, farms, mining camps, Indigenous territories, and villages, but mainly in the region's cities, invisible in the non-Amazonian public's imagination of the Amazon as a pristine forest. These areas are home to food production, small animal raising, and interaction between riparian, "backyard," and other urban resources. Multi-sited households and family networks shape the urban and rural landscapes of the region, supporting well-established patterns of trade and exchange across short and long distances. **CH14**

BKG 8.2. The settlement patterns of Amazonian populations are highly complex and dynamic, including diverse migration patterns by people internal and external to the region and between urban and rural areas. The mixture of rural and urban activities includes peri-urban production; multi-sited households living off periodic urban and rural waged work; episodic migration; state transfers such as conditional cash transfers, pensions, and remittances; and engagement in informal and clandestine economies. Amazonian urban areas also experience significant crime and violence, reflecting the dynamics of poverty, inequality, and illegal activities. The Brazilian Amazonian state capitals of Manaus, Belém, and Macapá are among the 50 most violent cities in the world, 41 of which are in Latin America. **CH14**

MESSAGE 9

Approximately 18% of Pan-Amazon have been converted to other land uses, and at least an additional 17% have been degraded within the biome. The interplay between different direct and indirect drivers determines the dynamics of land-use change in Amazonian countries. Historical oscillations in the rate and location of forest loss also reflect responses to development policies, national and transnational political decisions, economic forces, environmental law strategies, political instability, and the lack of institutional capacity to detect legal and illegal deforestation.

BKG 9.1. Deforestation has intensified substantially since 2019 in the Basin, albeit at different rates in individual countries. Most deforestation has been concentrated in Brazil, which lost c. 457,237 km² of forests between 1988 and 2020. In the Brazilian Amazon, annual deforestation between 2019 and 2020 was more than 10,000 km², a level not reached since a decade earlier (2008). In the Colombian Amazon, annual deforestation rates have been in decline since 2017, but increased in 2020, reaching 1,090 km². Human actions are the direct drivers of deforestation, including the expansion of pastures and croplands, the opening of new roads, the construction of hydroelectric dams, and mineral and oil exploitation. Indirect drivers influence human actions, such as poor governance, institutional structures, policies, or commodity market conditions. Because multiple drivers simultaneously affect deforestation rates, it is challenging to estimate their isolated impacts. **CH19**

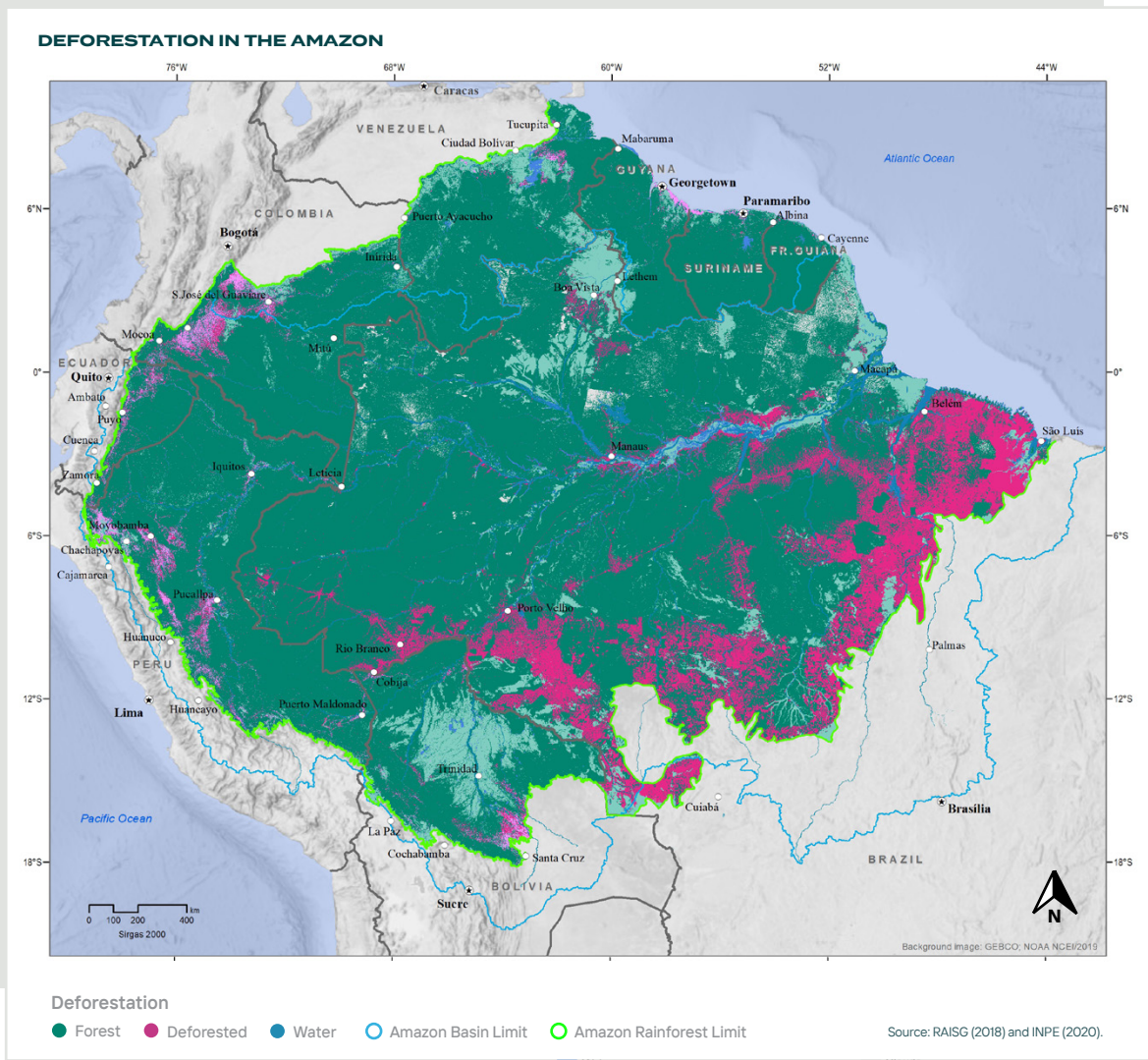


Figure 6. Forest cover and accumulated deforestation in the Amazon biome. Chapter 19.

BKG 9.2. Agricultural expansion, particularly cattle ranching, remains the most important driver of Amazonian deforestation. In the Brazilian Amazon, estimates indicate that active or abandoned degraded pastures occupy 80% of deforested areas. In the early 2000s, the expansion of large-scale croplands occurred. Conservation policies such as the soy moratorium and the creation of several new protected areas where soy-related deforestation was taking place attenuated the expansion, although to some degree the reduction in deforestation in the Amazon can be associated with leakage to the Cerrado and Chaco. In Bolivia, soy is still expanding; the region of Santa Cruz has been identified as the largest deforestation hotspot in the Amazon, mainly due to forest conversion to soy fields. Although road construction and mining cause direct deforestation when forest area is lost to these activities, their indirect impact is more significant. Both activities stimulate migration, the expansion of the agricultural frontier, urbanization, and new settlements. **CH15, CH19**



Figure 7. Agricultural expansion pressure on protected areas. Floresta Nacional do Tapajós, Belterra, abril de 2019. Photo: Marizilda Cruppe/ Rede Amazônia Sustentável (RAS)

BKG9.3. Several anthropogenic disturbances can lead to forest degradation in the Amazon, including forest fires, illegal selective logging, edge effects, and hunting. Experts estimate that 366,300 km² of forests were degraded between 1995 and 2017. Forest fires may have the greatest effect on carbon loss. In most years, and in most undisturbed forests, high moisture in the understories of Amazonian forests keeps flammability levels close to zero. However, every year thousands of hectares of forests, mostly degraded, burn across the basin as fires escape nearby pastures or recently deforested areas. Forest fires spread slowly, have flame heights of 30-50 cm, and release little energy (≤ 250 kW/m). Nonetheless, they have a significant influence as Amazonian forests have not evolved to cope with fire. Even low intensity fires can kill around 40% of stemmed plants and extirpate many animal species that forage in dark understories. These effects last for decades, and it is currently unknown whether or not forests will ever return to baseline levels. **CH19**

MESSAGE 10

A network of more than 6,000 Indigenous territories (ITs) and protected areas (PAs) across eight countries and one national territory cover around 50% of the Amazon basin. They are one of the cornerstones of conservation and the self-determination and land rights of IPLCs. ITs and PAs show lower deforestation rates relative to unprotected forests; however, they are under continuous threat from the expansion of the agricultural frontier, infrastructure development, overlapping extractive concessions, and policies aiming to change their limits and level of protection.

BKG 10.1. There are 563 PAs in the Amazon basin, and they cover 25% of its surface. By country, the protected proportion varies between 21% in Peru and 51% in French Guiana. Over time, countries have increased the number of protected areas, except for French Guiana and Venezuela, where protected areas have remained stationary for the last two decades, and Ecuador, where there has been little variation. In the Amazon basin, 6,443 ITs are identified, which cover approximately 27% of the region. In the basin, 89% of the surface area of ITs is officially recognized, 6.5% lacks legal protection, and the remaining 4% are Indigenous lands (proposed or existing) and intangible zones. CH16

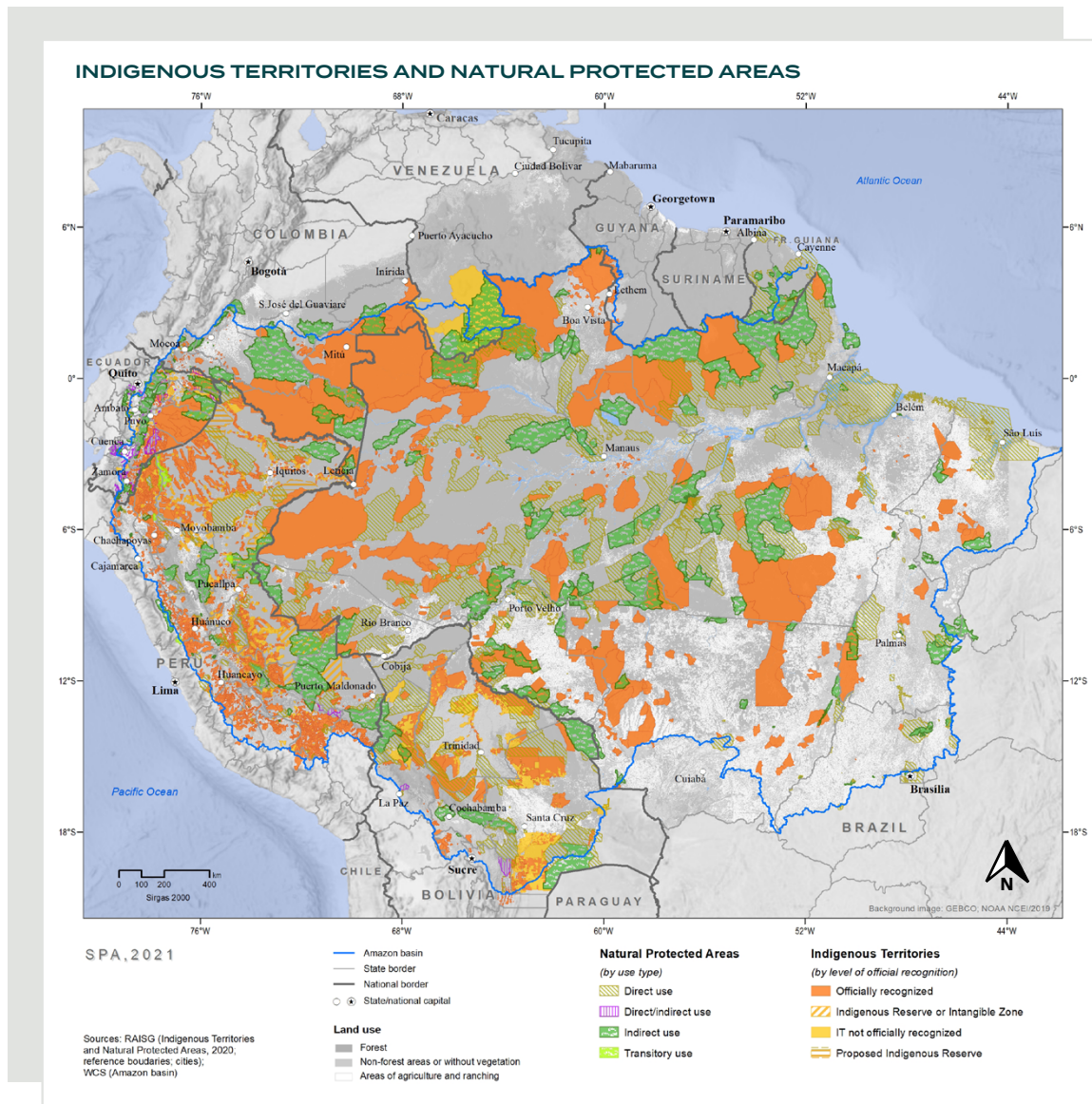


Figure 8. Protected areas and Indigenous territories in the Amazon basin. Chapter 16

BKG 10.2. It is estimated that 51% of PAs are under some type of pressure, the majority with moderate or low rates driven by infrastructure. Similarly, 48% of ITs are under pressure, and one-third face high to very high rates from unsustainable extractive activities and infrastructure development (i.e., energy and roads) on more than half of their area. Between 2001 and 2018, new agricultural areas within PAs increased by more than 220% and covered 53,269 km², 74% of which had forest cover in 2000. Deforestation has also increased within Indigenous territories, where 42,860 km² were converted to

agriculture, 71% of which were forests in 2000. Annual deforestation in all ITs varied between 1,000 and 1,700 km² between 2001 and 2016 but rose significantly in 2017 and 2018 to 2,500 km² and 2,600 km², respectively. **CH16**

BKG 10.3. Despite the pressures PAs and ITs face, they are unquestionably essential for conserving the Amazon rainforest and freshwater ecosystems. Between 2000 and 2018, only 13% of the total deforested area in the Amazon basin was located inside ITs and PAs, even though they collectively cover more than half of the region's forests. There is a clear upward trend in deforestation since 2015. Although 87% of the deforestation took place outside of PAs and ITs, respectively, 8% and 5% occurred in these units, with 2017 and 2018. It is worth highlighting that comparative analyses looking at deforestation in legally-recognized ITs versus unrecognized ones conclude that full legal status significantly reduces deforestation. This reaffirms the importance of demarcating Indigenous lands to conserve Amazon forests, rivers, and peoples. **CH16**

MESSAGE 11

The warming of the Amazon is a fact, and the last two decades have been the warmest recorded since the last century. Today, the Amazon is about 1.2°C warmer, a value higher than the global average of 1.1°C, and with annual mean warming trends over the entire Amazon. Increased frequency of extreme climate events (floods and droughts) is impacting Amazonian ecosystems and their functioning. *Terra firme* forests are susceptible to drought and fires, while floodplain systems are vulnerable to changes in flood regimes. Land-use changes reinforce global climate change, leading to positive feedback mechanisms that reduce forest resilience. They also increase drought stress and fire risk, turn the Amazon into a carbon source, cause higher tree mortality, and ultimately could reach a tipping point where continuous forests can no longer exist and are replaced by degraded forests. These cascading effects would have tremendous impacts on climate and in turn agriculture, hydropower generation, and human health and well-being.

BKG 11.1. Since the 1960s, the temperature in the Amazon has reached two major peaks with an increase of 1.2 °C in 2015-2016 and of 1.1 °C in 2019-2020. Future warming of 4°C or higher, as some scenarios project, may induce changes in the hydrological cycle and in the functioning of the forest. Models of high emission scenarios project progressively higher warming that may exceed 6°C in the second half of the century, particularly during the region's dry and dry-to-wet transition seasons. There is agreement between models that annual mean precipitation will drop in the Amazon, with a more significant decline in the eastern and southern Amazon. They also consensus that precipitation

will increase across the northwestern Amazon at the end of the 21st century, with consequences for the region's hydrology. Declining evapotranspiration, total runoff, soil moisture, and available water are also observed in the Amazon. The dry season is expected to extend in duration over the southern Amazon. In the Peruvian-Ecuadorian Andean-Amazon basins (Marañón basin), an expected increase in precipitation seasonality might augment the severity of wet season floods. In contrast, in the southern Peruvian and Bolivian Amazon, reduced precipitation is expected during a longer dry season, reducing runoff in the Bolivian Amazon and southern Peruvian Amazon during the low-water season. A future reduction in easterly winds at 200 hPa (<12 km altitude) is projected during the austral summer, which could translate into reduced rainfall in the Andes-Altiplano (-10% to -30%) and probably over the highest regions of the upper Amazon by the end of the 21st century. Glaciers, a critical water source for cities in the upper Andes, are retreating at unprecedented rates, which have accelerated since the late 1970s. As a result, air temperatures are expected to increase by the end of the 21st century, and many glaciers could disappear, increasing the risk of water scarcity in upper Andean valleys. [CH22](#)

BKG 11.2. A longer dry season and later onset of the rainy season may directly impact fire risk and regional hydrology, increasing vulnerability to drought. Furthermore, aerosols produced by late dry season biomass burning contribute to alterations in the onset of the rainy season, possibly causing feedback that enhances drought conditions. Interannual precipitation reduction due to El Niño or a warmer tropical North Atlantic may reduce atmospheric moisture transport and respective recycling of precipitation due to deforestation and land-use change in climate-critical regions. This induces a self-amplified drying process which would further destabilize Amazonian forests in downwind regions, i.e., the southwestern and southern Amazon regions, and reduce moisture export to west-central Brazil (including the Pantanal), southeastern Brazil, the La Plata Basin, and the Andean mountains. In these downwind regions, reduced moisture transport from the Amazon may favor drought, increase fire risk, decrease water availability for rainfed agriculture and fishing, and affect energy security in regions to the south of the Amazon. Hydropower plants in the coming decades may operate less than half of the time because the minimum river flow will not be reached. Fisheries, which contribute more than USD 400 million annually across the basin and support about 200,000 fisherfolk in Brazil alone, will be impacted by climate change. [CH22](#), [CH23](#)

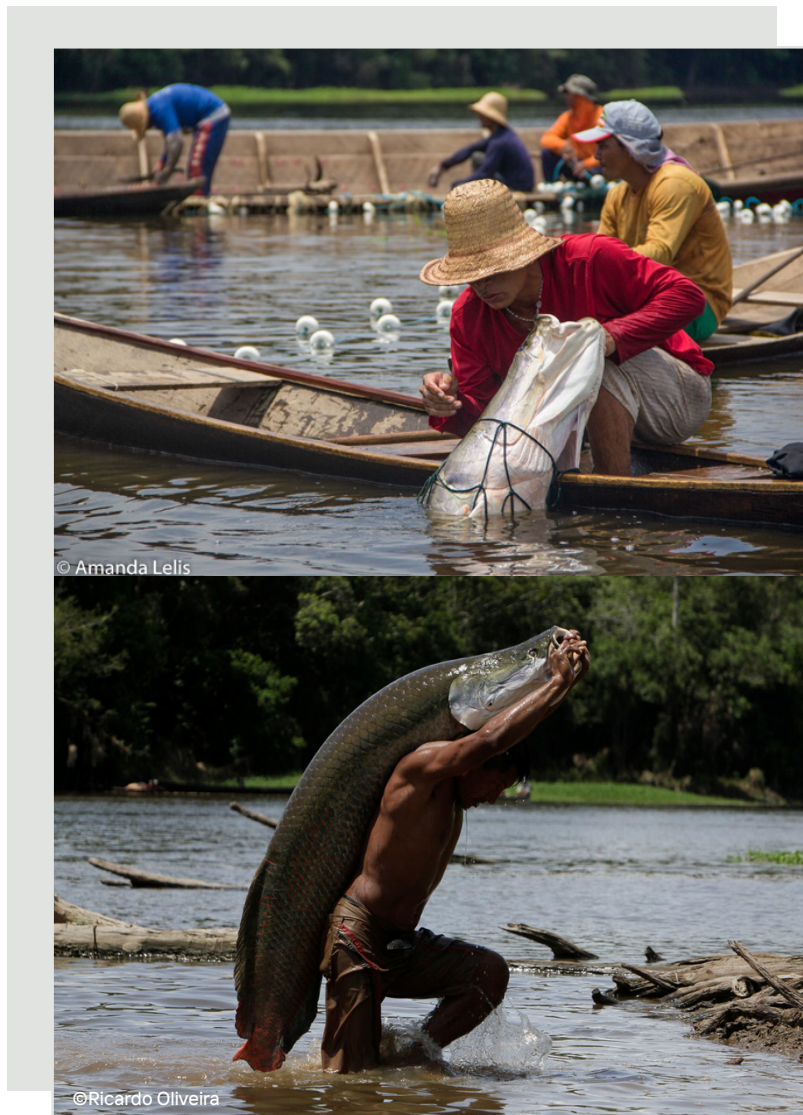


Figure 9. Fishing resource management activities in different parts of the Amazon. Photos provided by Helder Lima de Queiroz.

BKG 11.3. The most severe impacts of climate change are often related to changes in climate extremes. Within the last two decades, extreme droughts have become more frequent, and precipitation extremes during the wet and dry seasons have intensified with interannual variability. A fivefold increase in severe flood events resulted in increased flood hazards over the last two decades in the central Amazon (particularly 2009, 2012-2015, 2017, 2019, 2021). Regional discharge has increased in the northwestern Amazon during the high-water season (1974-2009) and decreased in the southwestern Amazon during the low-water season (1974-2009). Human-induced disturbances (e.g., wildfires and deforestation) and climate change act synergistically, amplifying their impacts on biodiversity and ecosystem processes. Deforestation and degradation may reduce evapotranspiration by 30% or more, increasing surface temperatures. Some regions are more likely to be affected by synergistic effects between deforestation and climate change; the eastern Amazon may suffer up to 95% of forest loss by 2050, followed by the southwestern (81%) and southern Amazon (78%). Furthermore, deforestation and climate change interact to significantly increase fire risk and the prevalence of forest fires. [CH19](#), [CH22](#)

BKG 11.4. Observed increases in temperature, precipitation changes, and climate extremes affect ecosystem services and carbon uptake. Wood productivity is suppressed when maximum temperatures are reached and seasonal water deficits are high. The Amazonian carbon cycle can be disrupted abruptly, with long-lasting effects from forest disturbances, both natural and anthropogenic. These are associated with climate-driven intensification of seasonal cycles, which is further exacerbated by interactions between deforestation and climate change. Some Amazonian forests are already at the climatic limits beyond which they will be incapable of sustaining productive forest ecosystems. The carbon sinks of mature forest have weakened by around 60% in just three decades in the basin. In response to anthropogenic disturbance and climate change, estimates indicate that overall the Amazon has been a carbon source to the atmosphere in recent decades. Carbon emissions from deforestation contribute to increases in atmospheric greenhouse gas (GHG) concentrations and temperature globally, which are also expected to increase forest water use efficiency through CO₂ fertilization and reduce the amount of water vapor recycled to the atmosphere. Forest resilience will likely be reduced due to feedbacks and increased fire, leading to the crossing of a tipping point and an irreversible shift to other types of vegetation and landscape configurations. Humid forests over nutrient-rich soils may shift into a closed-canopy state that resembles, in terms of structure and functioning, a seasonally dry tropical forest dominated by fast-growing deciduous trees. Savanna-like vegetation could replace forest areas and persist due to feedback mechanisms involving repeated wildfires and soil erosion, although any resemblance to natural savannas is likely to take centuries or longer. Forests may also be trapped in a disturbed state, recovering their closed-canopies but not progressing towards a mature forest and having lower biodiversity and carbon storage. **CH06, CH23, CH24, CROSS-BOX AMAZON CARBON BUDGET**

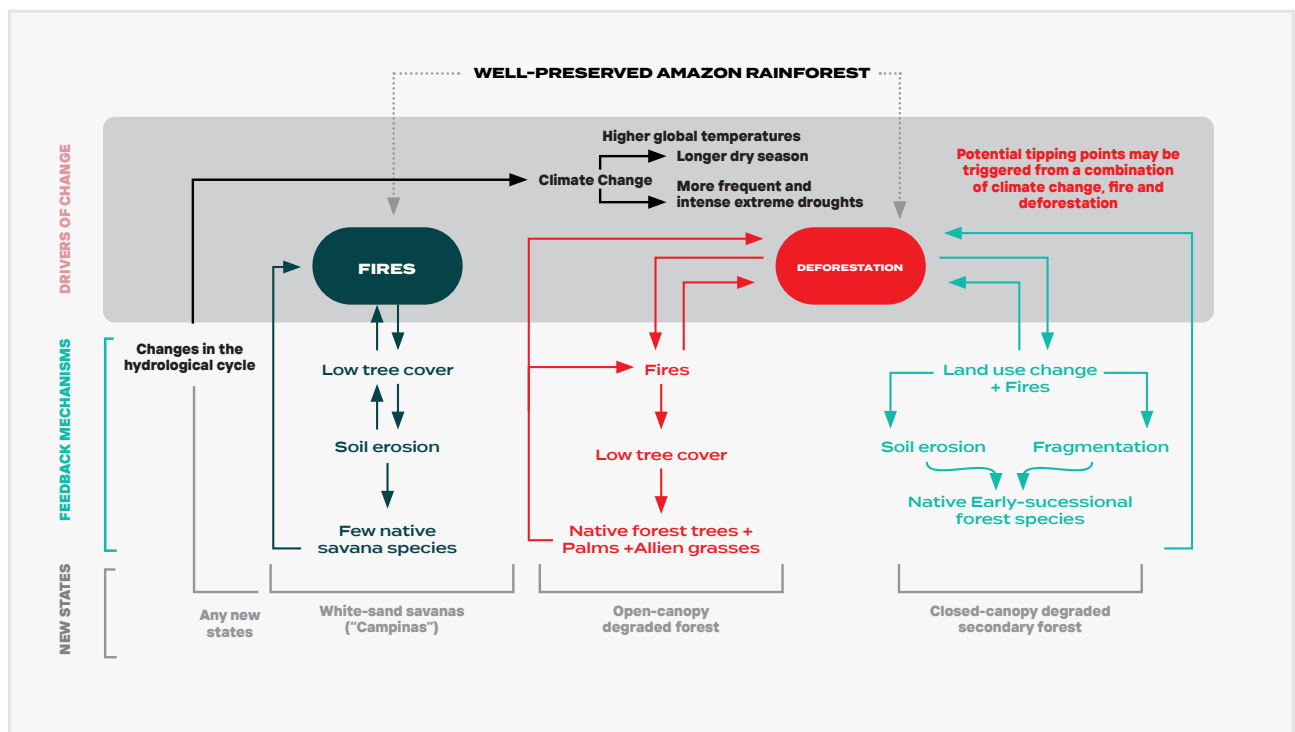


Figure 10. Simplified diagram illustrating the drivers of change that can lead to tipping points in the Amazonian rainforests. Drivers of change refer to direct (i.e., higher global temperatures) and indirect (i.e., longer dry season and more frequent and intense extreme drought events) large-scale climate change effects, followed by regional to local scale wildfires and deforestation. If tipping points are crossed in current drivers of change, either individually or in a compound way, the depicted cascading chains of impacts resembling a domino effect, called feedback mechanisms, are key to trap rainforests into three different potential states already registered and documented within Amazonian rainforest: white-sand savanna (or "Amazonian campinas"), open-canopy degraded forest or closed-canopy degraded secondary forest. Chapter 24

MESSAGE 12

The biodiversity of terrestrial and freshwater ecosystems is under threat due to deforestation, habitat fragmentation, overexploitation, pollution, and climate change, both in the tropical Andes and lowland Amazon. Anthropogenic disturbances have put plants and animals, both terrestrial and aquatic, at high risk of extinction, particularly those with restricted geographical ranges. It is also changing the functioning of forests and other ecosystems, impacting carbon storage and sequestration, decreasing its productivity and resilience to disturbance, and disrupting the natural hydrological cycle, affecting the capacity of the Amazon Basin to supply goods and services essential to humanity.

BKG 12.1. Biodiversity loss is extremely concerning, with several species of trees, mammals, birds, reptiles, amphibians, fish, and terrestrial invertebrates classified as endangered. Some species are Critically Endangered, and some of the endemic birds and mammals of the eastern Amazon have populations in the tens or hundreds. Of the more than 15,000 Amazonian tree species, 36%-57% are likely to qualify as globally threatened under the International Union for Conservation of Nature (IUCN)'s extinction risk criteria. The numbers of endangered species are highly conservative, as most Amazonian species have not even had their status assessed. Although, to date, there is no record of a regional extinction, some may have already occurred, especially in plants and invertebrates, given a large number of undescribed species in these taxa. On the other hand, records of local extinctions abound, with several species now restricted to tiny portions of their original range. Due to their restricted distributions, Andean species are at a greater risk of extinction than Amazonian species, as seen in Colombian birds. Extinctions have cascading effects, through pollination and consumption networks, which fundamentally change ecological interactions and threaten Amazonian biodiversity.

CHO3, CHO4, CH19, CH27

BKG 12.2. Widespread in the Amazon basin, deforestation is the main driver of ecological impacts on the terrestrial ecosystems, transforming species-rich forested areas into species-poor agricultural lands and transforming contiguous forested areas into isolated patches, disrupting dispersion and movement of both animals and plants, with consequences for the maintenance of viable populations. Stream fragmentation by hydroelectric dams and other infrastructure (e.g., roads) alters ecosystem processes by modifying trophic cascades, blocking fish migrations and the transport of sediments and associated nutrients, and altering river flows and oxygen levels, which, in turn, alter the productivity of aquatic ecosystems. Overexploitation and illegal trade reduce populations of Andean-Amazonian vertebrates. Most commercial, overexploited fish species in the Amazon are migratory, traveling from a few hundred to several thousand kilometers, and most are at risk from the growing anthropogenic activities threatening Amazon aquatic ecosystems. Commercial fisheries

primarily target large-bodied species, which can disperse seeds of a broad size range and high plant diversity. Overharvesting threatens fruit-eating fishes and the biodiversity and conservation of the flooded forest, leading to food insecurity of local populations. Population declines in many mammals, reptiles, and bird species associated with over-harvesting are highest in the “arc of deforestation” and the Andes. Still, even intact areas have lost key species, having profound consequences for species composition, population biomass, ecosystem processes, and human well-being in over-hunted Amazonian landscapes. [CHO3](#), [CH14](#), [CH19](#), [CH20](#), [CH21](#), [CH27](#)

BKG 12.3. While deforestation is currently the most significant threat to biodiversity in the Amazon, climate change is becoming an increasingly relevant driver of biodiversity loss. Global climate change can affect the future distribution of biodiversity and the composition of ecological communities, species ranges, extinction probabilities, and local species richness. The Amazon is one of the regions most at risk, with more than 90% of species exposed to unprecedented temperatures by 2100. Andean-Amazonian fish species are especially susceptible to small temperature increases, which may cause unforeseen consequences in local food webs. Due to climate change, tree communities have become increasingly dominated by large statured taxa and drought-tolerant genera. In contrast, the mortality of wet-tolerant genera has increased in areas where the dry season has intensified. This suggests a slow shift towards a drier Amazon, with changes in compositional dynamics. Protecting lowlands’ connectivity to the cooler highlands and freshwater ecosystems may provide an escape path for many species from the Amazon and Andean foothills. Extreme flood events are also causing population declines in key species, reducing game-wildlife abundance that can shift local Indigenous people’s hunting efforts to fishing and increase local fishing pressure during the flood period. [CH22](#), [CH23](#)

BKG 12.4. The impacts of deforestation and forest degradation have local, regional, and global consequences. Local temperature and precipitation are affected by deforestation. Land surface temperature is between 1.0 - 3.0°C higher in pastures and croplands than in nearby forests, with this difference becoming more pronounced during the dry season. Furthermore, the more forest cover decreases at landscape scales, the hotter the landscape becomes. Landscapes with a lower number of remaining forest patches can be up to 2.5°C hotter than those with greater forest cover. Forest loss also leads to a reduction in precipitation. Forests recycle 28% of Amazonian rainfall on average; therefore, forest loss accrues a decrease in rainfall, which increases the risk of large-scale forest dieback. It is estimated that, to date, deforestation has already decreased precipitation by 1.8% across the Amazon, although changes in rainfall patterns vary across the basin and between the wet and dry seasons. Additionally, widespread deforestation negatively influences precipitation outside the Amazon basin, influencing regional hydrological cycles. On a global scale, GHG emissions are the most pronounced impact of forest loss in the Amazon. Amazon forest fires are estimated to contribute cumulative gross carbon emissions of around 126 Mg CO₂/ha for 30 years after a fire and a mean annual emission of 4.2 Mg CO₂/ha. Cumulative CO₂ uptake offsets 35% of these emissions (45 Mg CO₂/ha) within the same timeframe. Thus, one of the most uncertain components of the impacts of Amazonian forest fires is the magnitude of short- and long-term carbon emissions, and potential implications for CO₂ levels in the atmosphere and subsequent global warming. [CHO6](#), [CH19](#), [CH22](#), [CH23](#)

MESSAGE 13

Deforestation and degradation of both terrestrial and aquatic ecosystems have significant impacts on human health and well-being by increasing the incidence of zoonotic and respiratory diseases, cancer, and food insecurity, and exacerbating existing inequalities. In addition, fires, water and atmospheric pollution, and infrastructure development can result in human health impacts. These often exhibit synergistic effects on the most vulnerable people, including children, pregnant women, and marginalized IPLCs.

BKG 13.1. Forests and aquatic ecosystems are the basis for ecosystem services, which play a crucial role in people's livelihoods, human well-being, and health. Substantial evidence exists that environmental degradation can have acute and chronic impacts on human health, including the risk of contracting infectious diseases, respiratory problems caused by exposure to smoke from forest fires, and mercury (Hg) and other heavy metal contamination due to mining and other deforestation practices. Deforestation and associated degradation of terrestrial and aquatic ecosystems can facilitate the spread of infectious diseases and increase the likelihood of the emergence of new zoonotic diseases. Higher densities of the mosquito *Anopheles darlingi* are often associated with forest clearings and gold mining, increasing the risk of malaria transmission near forest edges and mining operations. The incidence of cutaneous leishmaniasis, which is transmitted by a common sandfly, has in some cases been correlated to deforestation. The presence of domestic animals can exacerbate disease incidence due to the acclimation of vectors to human landscapes. Despite existing evidence on the role of deforestation and forest degradation in disease outbreaks, the relationship between forest conversion and fragmentation and the incidence of infectious disease is complex, scale-dependent, and often modulated by socioecological feedbacks. In addition, the spatial matrix (e.g., pasture, urban area), the abundance of domestic animals, and specific human activities modulate disease burdens in complex ways. Environmental degradation is an ecological problem and a socioeconomic and health issue, affecting millions of Amazonians. There is an urgent need to understand the relationship between the individual and cumulative impacts of different environmental disturbances to better target policies to minimize their impacts. **CH21**

BKG 13.2. Surveillance efforts to identify hotspots of zoonotic coronaviruses with the potential to spillover to humans have categorized the Amazon as a region with an exceptionally high, yet poorly known, diversity of viral hosts and viruses. Other viruses circulate in the region and present severe risks, including the Rocio, Oropouche, Mayaro, and Saint Louis arboviruses, as well as hantaviruses and arenaviruses. Given the scant record, our understanding of the potential for land-use change to increase spillover risk remains limited. Nevertheless, global surveillance for viruses of zoonotic potential offers key lessons for preventing future zoonotic spillovers. Because the diversity of viruses in wild animal populations is vast, spillover potential for most viruses is limited. Close surveillance of

infectious diseases in the human population is an effective way to avert future pandemics. Region-wide improvements to public health services would also reduce the burden of well-known pathogens such as *Plasmodium* or *Leishmania*. CH21

BKG 13.3. Forest fires are a significant source of particulate matter and other pollutants, degrading air quality and affecting human health. Exposure to smoke is particularly high during the dry season when fires are commonly used to clear forests. The health effects are most acute for vulnerable groups such as children and pregnant women. Three of the main components of smoke are particulate matter less than 2.5 micrometers in diameter (PM_{2.5}), particulate matter less than 10 micrometers in diameter (PM₁₀), and black carbon – all of which are very toxic to humans. PM₁₀ can cause DNA damage and cell death, leading to the development of PM₁₀-mediated lung cancer, while PM_{2.5} and black carbon are associated with reduced lung function in children 6 to 15 years old. CH21

BKG 13.4. Mining is another source of impacts on human health. Gold mining sites are commonly associated with contamination by mercury (Hg). Communities living near gold mining operations are exposed to harmful Hg concentrations released during gold extraction and discharged into waterways, soils, and the atmosphere. Once anthropogenic activities release the inorganic metallic Hg, it is transformed into its more toxic organic form (methyl-mercury, MeHg) by specific bacteria, usually in anoxic conditions. This process of mercury methylation allows MeHg to enter aquatic food webs, where it may accumulate in individual organisms (bioaccumulation) or be magnified as it moves into higher trophic levels (e.g., biomagnification in predatory fish). Thus, it can affect fish that are of great importance for the food security of local communities. Mercury contamination has been linked to cognitive deficiencies and impaired motor capacity in children and adolescents across the Amazon; in adults, it affects the digestive, renal, nervous, and cardiovascular systems and can cause depression, extreme irritability, hallucinations, memory loss, tremors, insomnia, anxiety, altered tactile and vibration sensations, visual perimeter deficit, and ultimately death. CH21

PART 4

The Solution Space: Finding Sustainable Pathways for the Amazon



MESSAGE 14

A strategy to support a Living Amazon is based on three pillars: 1) Measures to conserve, restore, and remediate terrestrial and aquatic systems. 2) Developing innovative bioeconomy policies and institutional frameworks for human-environmental well-being, standing forests and flowing rivers, which includes investment in research, marketing, and production of Amazonian socio-biodiversity products. This must be supported with investment in science and education, and the creation of hubs and centers of excellence in technology in the Amazon. 3) Strengthening Amazonian citizenship and governance, which includes the implementation of bio-regional and bio-diplomatic governance systems (environmental diplomacy) to promote better management of natural resources and strengthen human and territorial rights.

BKG 14.1. Historic imbalances of power have led to the dominance of monetary-centric visions that reinforce the false rhetoric that standing forests do not produce socioeconomic development, destroying the Amazon’s ecosystems while maintaining inequalities and violence. These dominant narratives ignore IPLC’s alternative visions and historic practices, as well as their livelihoods, which depend on sustaining diverse natural systems and resources. The Living Amazon Vision proposes a new development model that is inclusive, just, and socially, environmentally, and economically healthy. It recognizes the role of the Amazon in the 21st Century, and the need for economies that can sustain ecological integrity and diversity, protect human rights, and promote well-being. Realizing the Living Amazon Vision is not trivial; it requires establishing a set of feasible solutions supported by governments, civil society, and private sector stakeholders. [CH25](#)

BKG 14.2. The meaningful participation of IPLCs is crucial to achieving a Living Amazon Vision. Amazonian-Andean Indigenous philosophies, concepts, and practices have inspired local, national, and international policies and social movements, including the Rights of Nature movement and associated policies, and the *Buen Vivir* (Good Living) and Pachamama concepts and values. These have been incorporated into national constitutions (Bolivia and Ecuador), and national, regional, and local development policies and practices. These principles and values should be articulated with economic instruments and global policies, including agreements on climate change, environment and biodiversity conservation, environment and social governance (ESG) arrangements, and normative frameworks such as the Sustainable Development Goals (SDGs). In addition, it is essential to secure land rights and the participation of IPLCs in decision making, including women, youth, and children. This will also contribute to addressing illegal activities, deforestation, and biodiversity loss, alleviating poverty and climate change risks. Linking traditional knowledge with current scientific knowledge and technology is key to reconciling the needs of humans and nature and moving towards a sustainable, inclusive, and equitable development path. [CH14](#), [CH15](#), [CH25](#), [CH26](#)

BKG 14.3. A Living Amazon Vision aligns with the Sustainable Development Goals. It is based on maximizing synergies between the different dimensions of sustainable development, recognizing the natural limits of Amazonian ecosystems, respecting human rights, deepening decentralized governance, controlling illicit activities, strengthening partnerships for conservation, and advancing sustainable development pathways. An alternative approach to the existing development paradigm is required because biodiversity loss, the risks of climate change, and the potential emergence of new infectious diseases compromise achievement of the 2030 Sustainable Development Agenda. On the other hand, the COVID-19 pandemic and our global ecological crisis are giving rise to the frameworks of “planetary health”, “well-being”, and “living economies”, which aim to promote human prosperity and protect the foundations of life on Earth. In this context, the Living Amazon Vision represents an opportunity for the region to be a global leader and example, recognizing the intrinsic value of nature, culture, and people in development, and breaking the dichotomy between conservation and aspirations for human well-being. [CH25](#), [CH26](#)

MESSAGE 15

A new cultural, economic, and political consensus for the conservation and sustainable use of the Amazon requires broad recognition of the spiritual, cultural, and physical relationships between humans and nature. Strengthening the cultural connection of urban dwellers with the forest and its people, with concerted interventions in various sectors, such as tourism, sport, and the visual arts, can provide a way to win over people's hearts and minds about the forest and its ways, securing its long-term existence. In addition, urban-rural physical dis- or misconceptions, such as those related to local economies, food security, healthcare, schooling, and green urban infrastructure, could all be ameliorated with well-planned participatory actions beneficial to both rural and urban dwellers.

BKG 15.1. Cultural capital supports economic, human, physical, and ecological/natural capital and is essential for resilient, sustainable livelihoods adaptable to crises. Undoubtedly, one of the major challenges facing humanity today is the loss of the vital connection between humans and the rest of the living world that sustains us. In the Amazon, the human population is increasingly urban and globalized. While Amazonian urban populations suffer permanently with widespread poor healthcare, education, and sanitation conditions, IPLCs, many of whom inhabit the outskirts of large cities, can face this urban-rural flux more fluidly, using both rural and urban environments more efficiently. [CH14](#), [CH26](#), [CH34](#)

BKG 15.2. It is of paramount importance for the well-being of our planet that we conserve the forest, maintaining its biological and carbon assets and cultural wealth. For instance, there cannot be a stronger link between rural and urbanized areas on food production without a new urban planning culture in the Amazon. The intercultural dialogue between Indigenous and scientific knowledge represents an opportunity to integrate cultural management practices into national or regional natural resources, such as watershed management plans. Alternatively, promoting sustainable tourism and sport in the forest is easier when there is greater access to healthcare in rural areas. Both policymakers and society in general (including urban- and forest-dwellers) need to promote these changes, bearing in mind that sustainability in the Amazon region has been, and will continue to be, shaped by its growing urban network and its connection to forest people and landscapes. [CH34](#)

BKG 15.3. Government resources and international cooperation in innovative programs play a decisive role in reducing the gap between the Amazon and the global scientific and technological innovation frontier. Actions can help finance research, innovation, and local industrialization, but also foster exchanges between countries on biodiversity knowledge and its potential utilization. The improvement of production techniques and the transparency of economic processes must consider

the communities that are the regions' protagonists. Local Amazonian communities must be integrally involved in planning, research, decision-making, and livelihood alternatives, linked to diversified markets, and expand their capacities and autonomy. Public and private actors will then be able to count on quality information, not only on production and prices, but also on the social conditions of the territories in which they operate. Within these ideas, ecological and externality accounting should play a key role. [CH30](#)

MESSAGE 16

Scaling up intercultural education and capacity building processes are key to preserving Amazonian people's identity and traditional knowledge and to connect, share, and build on diverse types of knowledge. This will support just, equitable, egalitarian, inclusive, and plural societies by providing opportunities and access to education to different peoples. Intercultural education consists of constructing spaces for dialogue between different cultures and their equitable interaction to generate shared cultural expressions.

BKG 16.1. Over the past 30 years, different stakeholders, from civil society to government agencies, have increasingly acknowledged the contribution of Indigenous and local knowledge to the Amazon's conservation and sustainable development. However, to address power imbalances concerning knowledge, academia and government agencies should build bridges for equitable and just collaboration with IPLCs and other non-academic knowledge holders. This includes training on intercultural contexts and knowledge and strengthening platforms for dialogue. Initial knowledge dialogue platforms may start at universities and research centers by including Indigenous and local knowledge holders and local experts on their faculties. [CH33](#)

BKG 16.2. In the Amazon, the notion of interculturality supports the cultural and linguistic richness of different worldviews and ways of interacting with the natural environment. Creating intercultural education and linguistic policies might be achieved by strengthening local governance and political-administrative autonomy in developing curricula; creating intercultural education proposals in the urban Amazon; creating bridges between primary, secondary, and tertiary education; and designing participatory curricular models with the possibility for technological innovation. Such a construct must also promote positive interaction with existing educational systems, including developing a broad, all-encompassing 'Pan-Amazon University.' [CH31](#), [CH32](#)

BKG 16.3. Pathways for intercultural education involve rethinking science in the Amazon with a new approach that systematizes and disseminates lessons learned and best practices of sharing knowledge, and applies these learnings to create relevant, just, and effective platforms and legal frameworks. Educational efforts should creatively address the lack of financial and technical

resources for connecting diverse ways of knowledge generation and sharing in the Amazon; ensure appropriate credit goes to IPLCs and other non-academic contributors to knowledge generation and sharing, and avoid mis-representing and mis-appropriating ILK in both conservation and development initiatives. Recognition of the knowledge held by Amazonian peoples is a potent tool in maintaining the extraordinarily rich socio-biodiversity in the region. [CH32](#)

MESSAGE 17

Biodiversity and forest conservation strategies are a priority for the maintenance and restoration of the remaining 83% of the Amazon forest (undisturbed and degraded) and associated bio- and cultural diversities. Mechanisms include law enforcement inside and outside PAs, the integration of PAs and sustainable agroecological systems in sustainable supply chains, incentives to restore degraded areas, improvement of management and financial institutions, civil society and social movement engagement, and new forms of environmental and resource governance. In addition, collaborative work between governments, civil society organizations, and Indigenous organizations for Andean-Amazonian connectivity offers a complementary opportunity, integrating the management of PAs and ITs for biodiversity conservation, and strengthening cultural connections and regional economic vitality across linked rural and urban systems.

BKG 17.1. Because the Amazon has both current and historical connections with many other Neotropical biomes, forest destruction and species loss have direct impacts at local and regional scales. The impacts and duration of degradation effects imply that conservation efforts should first focus on avoiding human-driven disturbances, retaining as much of the mature forest as possible. Conservation of the Amazon requires near-real-time monitoring of forest loss and forest degradation combined with effective on-the-ground enforcement actions at a regional scale with the participation of all Amazonian countries, and the further expansion and genuine protection of PAs and private forests, including policies that make sustainable use of resources work for both people and nature. Transparency around monitoring data supports efficient governance and avoids deforestation. The success of interventions designed to prevent deforestation and degradation requires better governance and reduced corruption at all scales. [CH27](#), [CH28](#)

BKG 17.2. For the successful management of PAs in the Amazon, it is necessary to: 1) Strengthen PAs as a source of benefits for local communities and direct users, designing concerted mechanisms for distributing benefits. 2) Encourage sustainable productive alternatives within PAs and their areas of influence. 3) Generate information for management and to validate the conservation status of

biodiversity, ecological processes, and cultural values. 4) Allocate adequate funds for the management of PAs. 5) Improve institutional capacities for the management of PAs, while considering governance implications. 6) Raise awareness of Indigenous and historical models and knowledge systems. **CH16, CH30**

BKG 17.3. The planning and management of PAs and ITs require well-defined goals for conserving biodiversity and ecosystem services, the participation of IPLCs, and the involvement of private stakeholders and other sub-national and local forms of government. Protection of ITs demands full recognition of territories and collective rights, and the strengthening of local governance as one of the most important strategies to maintain forests. Balanced and direct funding and capacity building for Indigenous peoples, organizations, and communities are essential to provide the necessary resources to continue to conserve forests. In addition to public lands and protected areas, private property also plays an important role in landscape connectivity, as is the case in Brazil. In the Brazilian Amazon, 80% of properties in forest areas and 35% in savannahs are protected under law - although smaller properties and those in "consolidated zones" have different requirements. **CH16**

MESSAGE 18

Stopping deforestation and forest degradation in less than a decade is challenging but still achievable. Restoration and rehabilitation of degraded forests and deforested or abandoned agricultural lands can provide national and regional policymakers opportunities to promote many direct and indirect economic and socio-environmental benefits to local people and society, with long-term international commitments. In addition, areas with existing infrastructure provide opportunities for rethinking Amazonian landscapes incorporating Indigenous peoples and local communities knowledge and practices.

BKG 18.1. It is estimated that between 1995 and 2017, more than 360,000 km² of forest in the Amazon biome was degraded and between 1985 to 2018 around 724,000 km² of forest in the Pan-Amazon was deforested (an area larger than France, Portugal, Belgium, and Netherlands combined). The potential and urgency for reforestation and restoration plans in the Amazon are also opportunities for new economic activities. Restoration is the active or passive recovery of an ecosystem or socio-economic condition and will be more effective if it considers complementary conservation measures, such as the protection of remaining primary forests. Diverse drivers across the basin have driven deforestation, and some regions are in greater need of restoration as they have very low levels of remaining forest cover; these include the Amazon/Andes transition (i.e., 500-1,300 m above sea level) and the more seasonal regions of the Brazilian "arc of deforestation". In these areas, restoration actions are opportunities to promote alternatives to deforestation and forest degradation, such as the development of timber production on deforested lands and promotion of diversified, sustainable livelihood systems that could relieve pressure on natural forests. **CH27, CH28**

BKG 18.2. Restoration options depend on the drivers of degradation or deforestation, the magnitude of the impact, and the socioeconomic context. Site-specific restoration options in terrestrial ecosystems include speeding up recovery after mining, reforesting the vast swathes of deforested land, facilitating the recovery of degraded primary forests, and restoring sustainable economic activities in deforested lands via sustainable intensification, agroforestry, or improving farm-fallow systems. Restoring aquatic systems requires applying techniques to remediate polluted aquatic and terrestrial habitats, including those affected by mining, petroleum, and plastic; developing and enforcing rules to reinstate natural flow regimes; and removing barriers that fragment rivers and disrupt connectivity. Restoration requires extensive technical support, and irrespective of the context, restoration may not recover ecosystems to their original form on meaningful timescales. However, the recovery of key ecosystem processes through active (e.g., tree planting) or passive (e.g., land abandonment) restoration may enhance ecosystem resilience and diversity. The high cost and complexity of many restoration options means they should be a last resort. For vast areas of the Amazon, the primary aim should be to avoid the need for future restoration by conserving mature forests and water bodies. [CH27](#), [CH28](#), [CH29](#)

BKG 18.3. Successful restoration needs to benefit local people, including restoring sustainable and socially just economic activities. Restoring and rehabilitating abandoned and unproductive agricultural lands will therefore be a priority. Effective restoration and remediation must focus on priority areas where multiple ecosystem services are maximized to a wide range of stakeholders across rural and urban networks, providing goods such as food or timber by planting tree species in agroecological systems. Restoration of riparian ecosystems enhances the connectivity of valued areas to endemic species and provides fundamental ecosystem services. Passive restoration (i.e., natural regeneration) and active restoration (i.e., promoted by humans), combined with silvopastoral and agroforestry systems, improve socioeconomic benefits. Opportunities for local actors include marketable non-timber forest products, such as fruits, resins, honey, or building materials. It is also important to consider context specificities through adapted technologies, innovations, and transformation pathways that address the multiple functions of agriculture, forests, and rural activities, boosting the learning processes by involving multiple stakeholders and their knowledge and experience rather than operating through technology transfer. Broader ideas, such as the “biocultural landscapes” derived from Indigenous and local knowledge systems could help support the restoration process. [CH29](#)



Figure 11. Community meetings for decision making related to the management of areas or natural resources. Photo provided by Helder Lima de Queiroz.

BKG 18.4. The most deforested regions of the Amazon are a high priority for restoration, as these older deforestation frontiers include some of the municipalities with the lowest Human Development Index values (HDI). Transforming unproductive lands into productive and sustainable agricultural or agroforestry systems could yield many direct economic and social benefits. The indirect effects of restoration, including regional climate regulation, could also be important for local economies. For example, maintaining or even reducing dry season length could enable the continuation of the 'double cropping' system that is vulnerable to climate change. In addition, these changing landscapes promote the emergence of new opportunities for increasing and diversifying supply chains, supporting innovation, creating jobs and income sources, and ultimately improving local people's well-being. **CH27**

MESSAGE 19

The bioeconomy synthesizes a set of ethical-normative values on the relationship between society and nature and its consequences on traditional activities of forest peoples, family farming, and commodity agriculture focused on socio-environmental sustainability. An innovative bioeconomy breaks down the contradiction between long-term conservation of natural resources and cultural capital and short-term economic gains which deplete those capitals. Enabling the development of a sustainable and dynamic bioeconomy in the Amazon requires halting illegal activities and environmental crime, strengthening the value chains of biodiversity products by merging scientific and traditional knowledge, and reducing information asymmetry. These actions ensure sustainability, transparency, and accountability throughout supply chains, stimulate entrepreneurship, and strengthen scientific and community ventures with public, private, national, and international investments. A post-pandemic green and equitable recovery may include a transition to a dynamic new bioeconomy financed by new financial mechanisms such as 'debt-for-nature swaps' as well compensation mechanisms for conservation and carbon sequestration.

BKG 19.1. Improving living conditions in the Amazon and strengthening markets for socio-biodiversity products are fundamental but insufficient. For humanity to enjoy the potential of one of the world's most biodiverse forests, it is essential to reduce the gap that separates the Amazon today from the global scientific and technological innovation frontier. This ambition presupposes the expansion of investments in science and technology in the region, especially from each country's public authorities. Unfortunately, the budgets of the most important research organizations in the Amazon are far from sufficient compared to the region's territorial, demographic, and natural importance and its potential to support the sustainable development of the countries in which it is located and humanity as a whole. **CH30**

BKG 19.2. A healthy bioeconomy in the Amazon can advance knowledge based on traditional beliefs and practices, science, technology, innovation, and strategic planning with reciprocity, equality, and participation. The transition to a knowledge economy is neither exclusively nor fundamentally technological, despite the crucial role of science and technology. It involves many enabling conditions, such as infrastructure, new markets, changing social preferences, and cultural changes in the social vision regarding forest socio-biodiversity. **CH30**

BKG 19.3. The emergence of a new bioeconomy of healthy forests and rivers in the Amazon should be supported by ambitious policies based on the socio-biodiversity knowledge associated with technological innovations whose use benefits people locally and globally. Applying science and technology to develop innovation in different sectors, such as agriculture and health (e.g., fertilizers, drugs, vaccines, nutraceuticals, and functional foods) represents the greatest opportunity to move the region from an economy based on commodities towards proper sustainable development. For example, innovation in pharmacological products, drugs, vaccines, genome sequencing, nutraceuticals, functional foods, and mining through bioleaching and living organisms can integrate the bioeconomy. **CH30**

BKG 19.4. A new bioeconomy of healthy forests and rivers cannot emerge as an enclave of scientific and technological advancement in a region so marked by poverty, inequality, violence, and lack of access to basic citizenship conditions, such as quality education, sanitation, healthcare, and participation in active labor and product markets. Cities concentrate the overwhelming majority of poverty and misery in the Amazon. The current forest socio-biodiversity economy depends on cities, where its products are consumed and most income is spent. In addition, even families whose livelihoods depend mainly on forest products seek to live in urban areas where essential health and education services are concentrated. Improving urban infrastructure, both in large centers and rural municipalities, is fundamental to the emergence of a dynamic bioeconomy. **CH30, CH33**



Figure 12. The metropolitan area of Manaus: an example of tensions between urban and rural context in the Amazon. source: AmazonFACE/Nitro/J.M.Rosa

MESSAGE 20

Partnerships and commitments among Amazonian and non-Amazonian countries, such as the Amazon Cooperation Treaty Organization (ACTO) and the Leticia Pact, as well as at sub-regional and state levels, are particularly important to 1) develop and implement effective environmental policies to avoid, mitigate, and compensate for the impacts of infrastructure and extractive projects on environmental assets and services, as well as people in the Amazon basin; and 2) enhance collaboration on science, technology, and innovation to advance a bioeconomy based on healthy forests and rivers.

BKG 20.1. The needed implementation of policy interventions at various scales includes: investment in infrastructure for knowledge dialogues and public participation, the collaborative creation of normative frameworks for just science, strengthening and scaling intercultural platforms and congresses, and structural change and training in the institutions that currently make decisions, to

make participation transparent and welcome. Additionally, the transformation towards a sustainable Amazon requires international agreements, regional cooperation mechanisms, financing, and regional partnerships at multiple scales and with different kinds of organizations to strengthen the exchange of information, monitoring to combat deforestation and degradation, local engagement, collaborative scientific development, and regional research institutions. **CH33**

BKG 20.2. It is crucial to accommodate and harmonize trans-regional and trans-national policies to protect neighboring biomes, as they are crucial to regional ecological integrity. Furthermore, implementing institutional agreements transcending political cycles can ensure continuity, as is also the case in addressing climate change. Between 2013 and 2015, approximately USD 1.07 billion were invested in regional environmental protection, mostly by bilateral or multilateral institutions. However, investments in infrastructure and energy projects that drive deforestation were much more significant. For instance, 33 major European financial institutions invested a combined total of USD 20 billion in companies directly involved in deforestation in Brazil from 2015 to 2020. Establishing a global partnership for a Living Amazon can address these inconsistencies, considering Amazonian ecosystems' critical regional and global role. **CH17**

BKG 20.3. Amazonian countries took an important step when the governments of Colombia, Bolivia, Ecuador, Peru, Suriname, Guyana, and Brazil signed the Leticia Pact, which includes commitments to share information, coordinate efforts to curb deforestation and wildfires, restore degraded areas in the region, establish early warning systems for deforestation and degradation, monitor climate change and biodiversity loss at a watershed scale, promote responsible consumption and the bioeconomy, empower women and Indigenous people, promote citizen education, and mobilize international finance in support of these objectives. Despite this agreement, recent data shows an increase in deforestation and forest degradation and persistent violence and poverty among Amazonian populations, pointing to the urgent need to combat events that degrade and destroy Amazon ecosystems. Such an agreement will require a paradigm shift, international commitments to reduce market forces currently driving deforestation, and the empowerment of multicultural partnerships between local stakeholders through decentralized bioregions, within and across national borders. In addition, progress at the bioregional level must be scaled and supported by multilevel governance at the national and basin level to distribute effective law enforcement, policy, and financial resources. Finally, the private sector, research institutes, and civil society organizations can build partnerships at different scales to support investment, science, innovation, and research that leverages biological and cultural diversity in the region. **CH30**

**This document is subject to final
copy-editing and changes in visualization.**

Living & Sustainable Amazon

The Solution Space



Figure 13. Multiple and connected dimensions for a fair and just transformation towards the Vision of the Living and Sustainable Amazon.

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