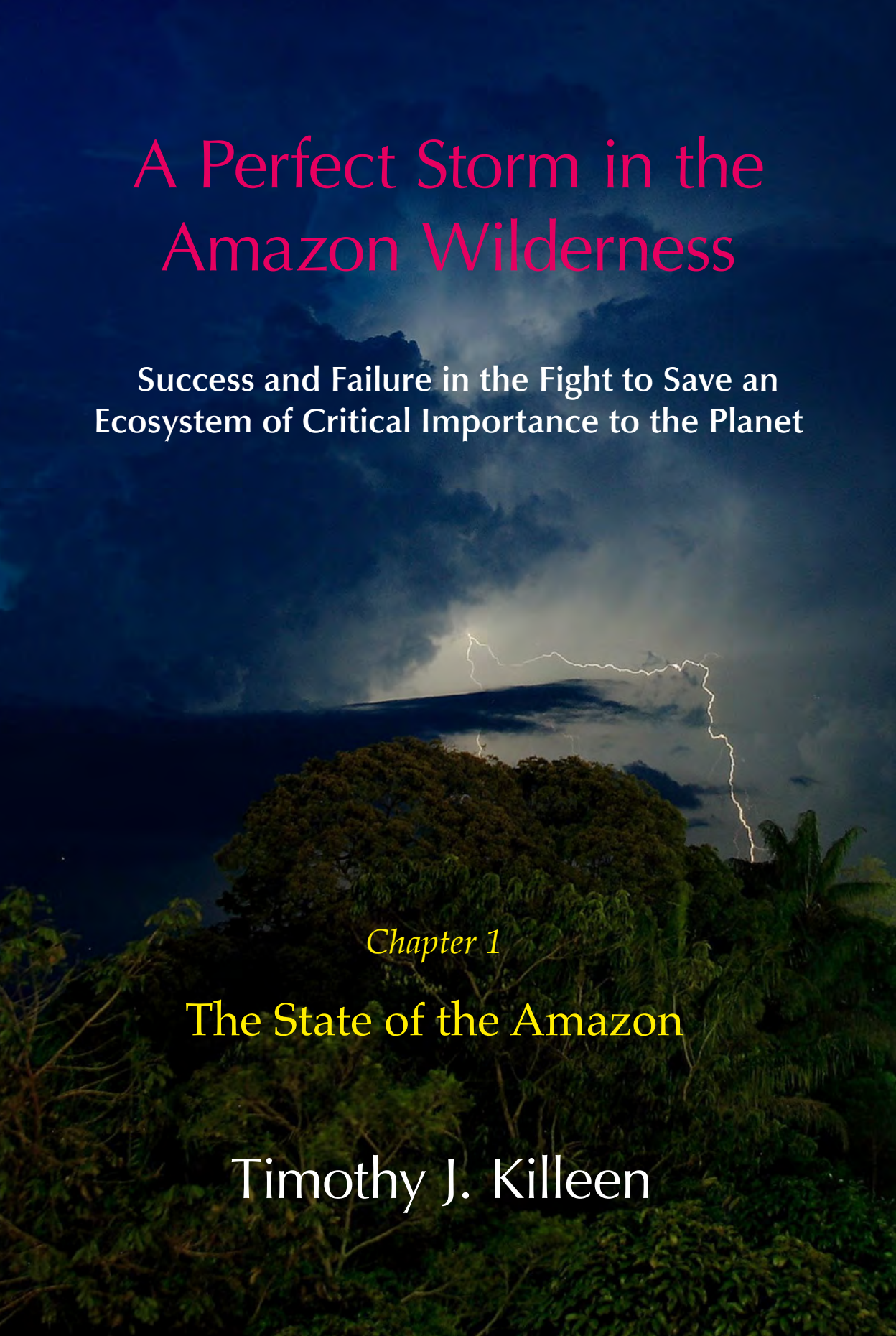

A Perfect Storm in the Amazon Wilderness

Success and Failure in the Fight to Save an Ecosystem of Critical Importance to the Planet

Chapter 1

The State of the Amazon

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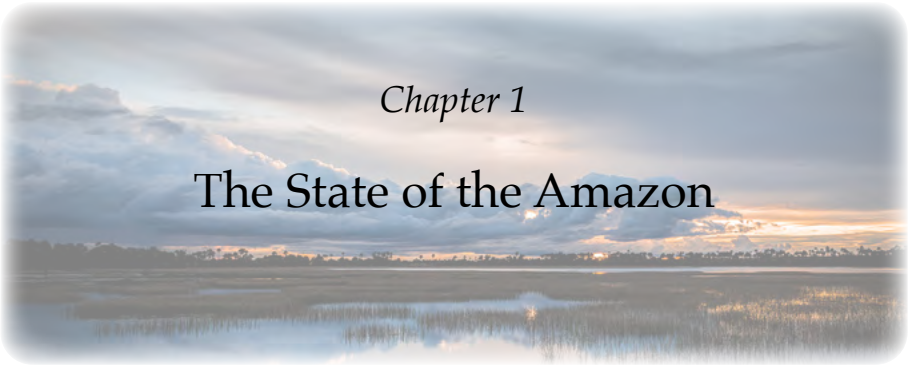
A Perfect Storm in the Amazon Wilderness
Chapter 1: The State of the Amazon

Contents

Figures, Tables and Text Boxes



Chapter 1

The State of the Amazon

The Amazon, home to the largest tropical forest on the planet, is an irreplaceable natural asset with enormous biodiversity and a critically important component in global carbon and water cycles. The Pan Amazon, which includes the full watershed and the rainforests of the Guiana Shield, is a geopolitical territory spanning nine nations that have been entrusted with the stewardship of its natural resources (Figure 1.1).

Fifteen years ago, the prospects for conserving this globally important natural asset were very much in doubt. Rampant deforestation driven by multiple social and economic phenomena threatened to transform its landscapes, degrade its aquatic resources and overwhelm its indigenous communities. Governments pursued construction of large-scale infrastructure projects as they sought to leverage unprecedented demand for global commodities with increased access to international financial markets. The resultant boom in economic activity motivated individuals and corporations to invest in business opportunities in the Amazon that progressively expanded the footprint of modern society. Climate scientists showed how a warmer planet would impact ecosystem function, as well as how a deforested landscape might disrupt moisture flows over the continent. The panorama was grim, and the combination of threats was referred to as *A Perfect Storm in the Amazon Wilderness*,[1] borrowing a phrase from popular culture that described the destructive synergies between multiple forces of change.

Fortunately, the citizens of the Amazonian nations were aware of the risk from uncontrolled development and demanded that their governments intervene to halt, or at the very least slow, the destruction. Concerned individuals from across the planet, in support of public and private conservation initiatives, joined them. The Pan Amazonian nations now boast the most extensive network of protected areas of any geographic region on Earth and have recognised the legal rights of indigenous communities by formalising their claims to ancestral lands. These two parallel efforts were

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implemented in a remarkably short span of time, reflecting the support of the area's constituent populations and the capacity of global society to mobilise financial resources for environmental action and social justice. Simultaneously, a dramatic reduction in deforestation rates gave hope to advocates seeking systemic changes in development paradigms, particularly in Brazil, where the agribusiness sector reformed its production systems after recognising that its commercial interests were best served by improving its environmental performance.

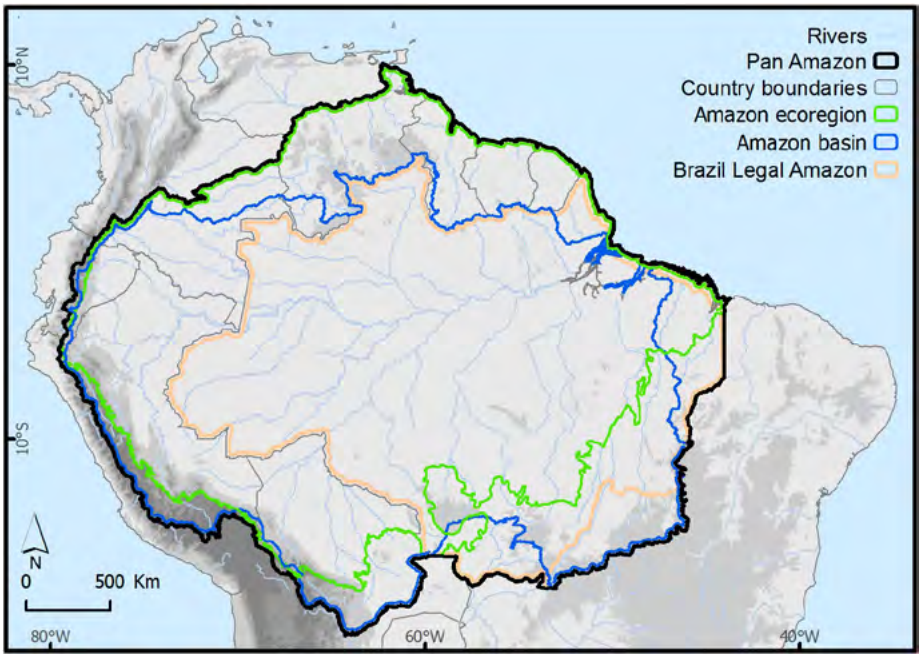

Figure 1.1: The Pan Amazon includes both the Amazon Ecoregion (green) and the Amazon Basin (blue). The southern boundary reflects Brazilian legislation governing fiscal and regulatory policy referred to as the Legal Amazon (tan).

Data source: Amazon Cooperation Treaty Organization.

The success of conservation initiatives and the decline in deforestation are essential for the long-term survival of the Amazon, but they have not changed the long-term trajectory of the Pan Amazon. Fully sixty per cent of the region remains open to non-sustainable activities, including logging, artisanal gold mining and settlement by small-scale farmers. Deforestation rates have crept upward across the region and registered historical highs in Colombia, Peru and Bolivia. Worse still, the predicted impacts of climate

The Amazon is the world's largest intact tropical forest wilderness. The Río Javari on the border between Peru and Brazil.

change have manifested, in part due to increasing temperatures but, more ominously, by modifying precipitation regimes that threaten to tip the region – or at least its southern half – into a cataclysmic shift in ecosystem function that could lead to widespread forest dieback.[2]

Recent events, particularly the increase in forest fires and an election in Brazil, have placed Amazonian conservation once again in the forefront of the global media, which is now dominated by social networks that have succeeded in dramatising the issue at the local, national and international levels. Societies are demanding solutions, but these will be neither easy nor simple because the causes of environmental degradation in the Amazon are complex and span infrastructure, agriculture, minerals, finance and governance. Meaningful reform is impeded by the predominance of conventional business models, reinforced by deeply ingrained cultural attitudes, corruption, and inequality. The response to the COVID-19 pandemic exposed the inability of governments to safeguard their populations, particularly indigenous communities whose fear of disease is rooted in centuries of experience, as well as the rural and urban poor whose endemic exposure to infectious diseases and parasites increases the risk of mortality and morbidity.

Changing the development pathway of the Pan Amazon is like turning an ocean liner; steady pressure must be applied to the rudder of state over a long period in order to drive incremental change across multiple sectors of the regional economy. Regulation and market incentives that influence human behaviour and corporate decisions must be aligned with conservation outcomes so that sustainable development is less aspirational and more operational. This will require profound reforms in financial and commercial markets, as well as real change in regulatory systems and enhanced law enforcement. With few exceptions, sustainable models in forest and fisheries management have not yielded the economic returns needed to make them competitive with conventional extractive models. Even worse, the monetisation of ecosystem services has generated a mere fraction of the resources required to change human behaviour on the forest frontier, much less to subsidise the reforestation efforts that climate scientists view as essential for stabilising the hydrological regime of the Southern Amazon.

This second edition of *A Perfect Storm in the Amazon Wilderness* provides an overview of the topics most relevant to the conservation of the region's biodiversity, ecosystem services and indigenous cultures, as well as a description of the conventional and sustainable development models that are vying for space within the regional economy. Events of the last ten years are discussed in detail because future events will have to build upon – or modify – the cultural and economic forces driving events in the Pan Amazon. The text provides a longer historical perspective to show how policies create legacies that reverberate over decades, long after they have been recognised as being fundamentally flawed.

Drivers of Environmental Degradation

Why do people clear forest? To anybody who has lived on the forest frontier, the answer is as simple as it is obvious: it is essential to the livelihoods of the region's inhabitants. In some cases, it may be to grow food to feed a family but, more often, people clear forest to generate wealth by selling timber, cultivating a crop or raising livestock. The flow of goods between rural and urban societies is as old as civilisation, but in today's global economy the connection between the producer and the consumer is mediated by a supply chain that is complex and not particularly transparent. For the last several decades, increases in demand for food and fibre have been met by the expansion of agricultural supply chains into tropical forest wilderness. Producers operating on these landscapes are responding to global demand for the goods they produce; they are acting in their own self-interest to create wealth for their families and jobs for their communities (Chapter 3). Many are fully aware that deforestation is a global problem but maintain

Photograph © Rhett Butler, courtesy of Mongabay.

Santa Cruz, Bolivia

© Paula Vilela / shutterstock.com.

Mato Grosso

The production of beef cattle is the largest driver of deforestation and a mainstay of the rural economy in the Southern Amazon. Landholders clear forest on the forest frontier where land can be acquired via illegal or legal transactions. Over time, ranchers increase pasture area by clearing remnant forest, while improving productivity through grazing management, feed technology and animal genetics.

that they should not bear the cost of conserving biodiversity or fighting global warming, especially when wealthy nations have sacrificed their own forest and polluted the atmosphere in pursuit of economic growth. A common refrain, voiced across economic spectra, is that wealthy nations should assume the cost of forest conservation.

Many consumers in wealthy nations are concerned about tropical deforestation, and some express a willingness to pay for conservation measures. Nonetheless, many are unaware that the food they eat or the shampoo they use has been manufactured using products that originate from recently deforested landscapes. Consumers are isolated from producers by a host of middlemen, manufacturers and retailers, all of whom benefit from, and contribute to, the commercial forces that drive deforestation. Similarly, consumption of mineral commodities, such as iron ore, aluminum and petroleum, have contributed to the degradation of the forests and waters of the Amazon. The extractive industries impact the forest directly by operating mines and oil fields and indirectly when those facilities create access that opens the gateway for migration and the expansion of the agricultural frontier (Chapter 5). Financial institutions and individual investors who lend money or own shares in mining or petroleum corporations or agribusiness firms also share the responsibility for environmental degradation.

Deforestation is influenced enormously by the dynamics of rural real estate markets. Primary forest has value because its timber can be harvested for cash income but, once logged, land is referred to as 'unproductive' or as having 'productive potential'. In contrast, pastures, plantations and cropland are considered to be 'productive land' because they generate revenue. This may seem perverse to an ecologist who understands the potential long-term productivity of a forest, but clearing land generates cash flow over the short term and adds value to real estate assets over the medium- and long-term (Chapter 4).

Public policies also foster deforestation. Most Amazonian countries have legal mechanisms for transferring public land to private individuals that explicitly allow – or even require – deforestation. Similarly, small-scale deforestation and the use of fire is either allowed or openly tolerated in almost all Amazonian jurisdictions. Local and regional governments, with the support of multilateral development agencies, build roads in wilderness landscapes where it is implicitly understood that land speculation will invariably lead to deforestation (Chapter 2). These policies remain in place because they enjoy the support of the economic interests of construction companies, landholders and agribusinesses, as well as the electoral power of landless peasants seeking a pathway out of poverty. Rhetoric supporting forest conservation is widespread, but acting to curtail deforestation is politically perilous. The potential for a political movement to drive deforesta-

Highways are deforestation vectors that improve access to previously remote areas, attracting settlers who clear land to establish farms and ranches. Road improvement is broadly supported by rural inhabitants because it facilitates commerce and increases land value. Aerial shot of an Amazonian highway in Ecuador and a clearing made by a subsistence farmer.

tion is exemplified by the election of Jair Bolsonaro, who campaigned on a promise to reverse the conservation policies of the previous three decades.

Culture also plays a role. Consider the pioneer who created a successful farm over a lifetime of hard work and is understandably proud of that accomplishment. His or her children and grandchildren are likely to have similar views – even if they now also hold views supporting forest conservation. Frontier societies are populated with individuals who believe conventional development is beneficial, a life-view reinforced by educational systems and spiritual leaders (Chapter 6).

Corruption is another obvious accelerant to the forces driving environmental degradation. The *Lava Jato* scandals associated with the construction of public infrastructure projects revealed how graft* distorted economic feasibility studies for projects that might have been rejected based solely on financial criteria.† It is often assumed that improved governance will empower environmental advocates and slow deforestation, but initiatives to decentralise administrative processes place decisions in the hands of local politicians who tend to favour conventional business models (Chapter 7).

Geographers and economists have created a classification system and lexicon to facilitate the discussion about the drivers of deforestation.[3] The term 'proximate causes' refers to those phenomena and actors directly responsible for deforestation; typically, these are on or near the landscape

* In the US English sense of obtaining advantage through dishonest use of power.

† *Lava Jato* (car wash) refers to a corruption scandal involving large construction companies and politicians in Brazil, which eventually spread to involve contracts and political leaders in the Andean Republics (Ch. 6).

Table 1.1a: Proximate causes of environmental degradation

• **Infrastructure Development** ° Trunk highways ° Secondary road networks ° Railroads ° Dams/waterways • **Agriculture** ° Beef ° Food crops ° Cash crops ° Illicit drugs • **Forest Production** ° Timber ° Wildfire ° Logging ° Hunting	• **Mineral Extraction** ° Industrial minerals ° Oil and gas ° Gold • **Land Speculation** ° Legal ° Illegal • **Governance** ° Corruption ° Administrative inefficiency ° Decentralisation ° Civil unrest • **Demographics** ° Population growth ° Migration

Table 1.1b: Indirect drivers and actors of environmental degradation

• **Global demand for agricultural commodities** ° Industrial crops: soy, beef, palm oil ° Cash crops: coffee, cocoa, sugar ° Timber, pulp, biofuels ° Illicit drugs • **National demand for basic food-stuffs** ° Protein: beef, dairy, poultry, ° Staples: rice, manioc, fruit • **Global demand for mineral commodities** ° Industrial metals ° Oil and gas ° Gold • **Market Intermediaries** ° Multinational corporations ° State-owned monopolies ° Domestic conglomerates	• **National regulatory framework** ° Food security and biofuel policies ° Land-use regulations ° Decentralisation processes ° Environmental review systems ° Inoperative judicial systems ° Regional development strategies ° **Financial institutions** ° Multilateral development agencies ° National development funds ° Direct foreign investment ° Domestic banks ° **Technical assistance and extension** ° Public extension services ° Grower associations ° Alternative development (illicit drugs)

being impacted by development (Table 1.1a). In many cases, there is an obvious link: cattle ranchers, for example, clear forest to expand pastures to raise beef. Sometimes there is a strong correlation but not a direct link: a new road cuts through a forest landscape, which opens access to settlers who spread out to establish homesteads.

Conversely, economists use the term 'indirect drivers' to describe factors that occur at considerable distance from the forest frontier but create an economic force that motivates the behaviour of individuals in frontier society. These include markets where commodities are traded, regulatory agencies that oversee land use and policies intended to promote economic growth (Table 1.1b). Because the influence is both indirect and distant, it may be difficult to establish the connection between cause and effect. For example, certain varieties of elite coffee that originate in specific montane tropical localities have become popular in North America and Europe. Demand for these coffees creates a premium that is paid to growers from these regions, which motivates them to expand their production by clearing the patch of forest next to their coffee grove.

The use of these terms and the stratification of the causes of deforestation may seem like an academic exercise with limited practical application, but it has been used to identify leverage points that can make supply chains more transparent and force intermediaries to modify their business practices.[4] Similarly, an evaluation of the drivers linked to regulatory frameworks or financial systems can identify the existence of perverse incentives that reward individuals or corporations that deforest land. Governments have recognised the need to reform laws, while multilateral agencies have embraced social and environmental standards that seek to avoid or mitigate the environmental impacts associated with their investments.[5]

The interactions between markets, regulatory systems, technology and culture are by definition complex, which is why it has been so difficult to stop deforestation.[6] Recent successes in reducing deforestation have been based on integrated approaches, which embrace the concept of incremental change and the need to involve all stakeholders with legitimate interests in the activities that cause, either directly or indirectly, the environmental degradation that threatens the Pan Amazon (Chapter 8).

The Geography of Environmental Degradation

The Pan Amazon spans approximately 825 million hectares, of which approximately ninety million hectares have been lost to deforestation; this corresponds to ~13% of the original forest cover (Table 1.2). At first glance, this percentage value might not seem alarming, particularly in the context of the total extant forest cover. However, cleared land is embedded within

Table 1.2: Original forest cover and deforestation in the Amazonian jurisdictions[25]

Country	Total Original Forest Cover (km^2)	Total Deforestation	Historical Deforestation (% of Original Forest Cover)	Deforestation 2010–2018 (km^2)	Deforestation 2010–2018 (% of Total Deforestation)
Bolivia	483,550	67,125	13.9	14,612	21.8
Brazil	4,243,362	670,861	15.8	50,035	7.5
Colombia	419,450	25,585	6.1	5,931	23.2
Ecuador	123,330	11,025	8.9	742	6.7
F. Guiana	75,000	650	0.9	360	55.4
Guyana	151,690	6,891	0.6	653	9.5
Peru	725,110	72,624	10.0	10,779	14.8
Suriname	146,931	6,683	0.7	723	10.8
Venezuela	396,335	13,063	3.3	1,740	13.3
Total	**6,764,758**	**874,507**	**12.8**	**85,575**	**9.8**

Text Box 1.1: Human-Modified Landscapes

Forest frontiers are highway or river corridors that penetrate or are adjacent to wilderness landscapes; residents and immigrant pioneers exploit timber resources and appropriate public lands by clearing forest to install low technology agriculture production systems.

Agricultural frontiers emerge after the improvement of trunk highways ensure year-round access and secondary roads are extended into surrounding forest. The rate of deforestation increases; forest remnants are progressively fragmented and isolated. Timber exploitation remains important, but agriculture increases in area and technological sophistication.

Consolidated frontiers are landscapes where pastures, fields, or plantations exceed forest cover; absolute rates of deforestation fall, but relative rates remain high as landholders clear forest remnants. Private sector investment in industrial infrastructure adds value to agricultural production, while the state improves basic infrastructure in urban centers.

Gold rush frontiers are similar to forest frontiers, but deforestation is caused by illegal gold miners who transform and destroy floodplain habitats. Access may be by road, river or light plane.

Coca frontiers are agricultural frontiers populated by settlers who clear small patches in the forest to cultivate coca leaf for illicit drug markets.

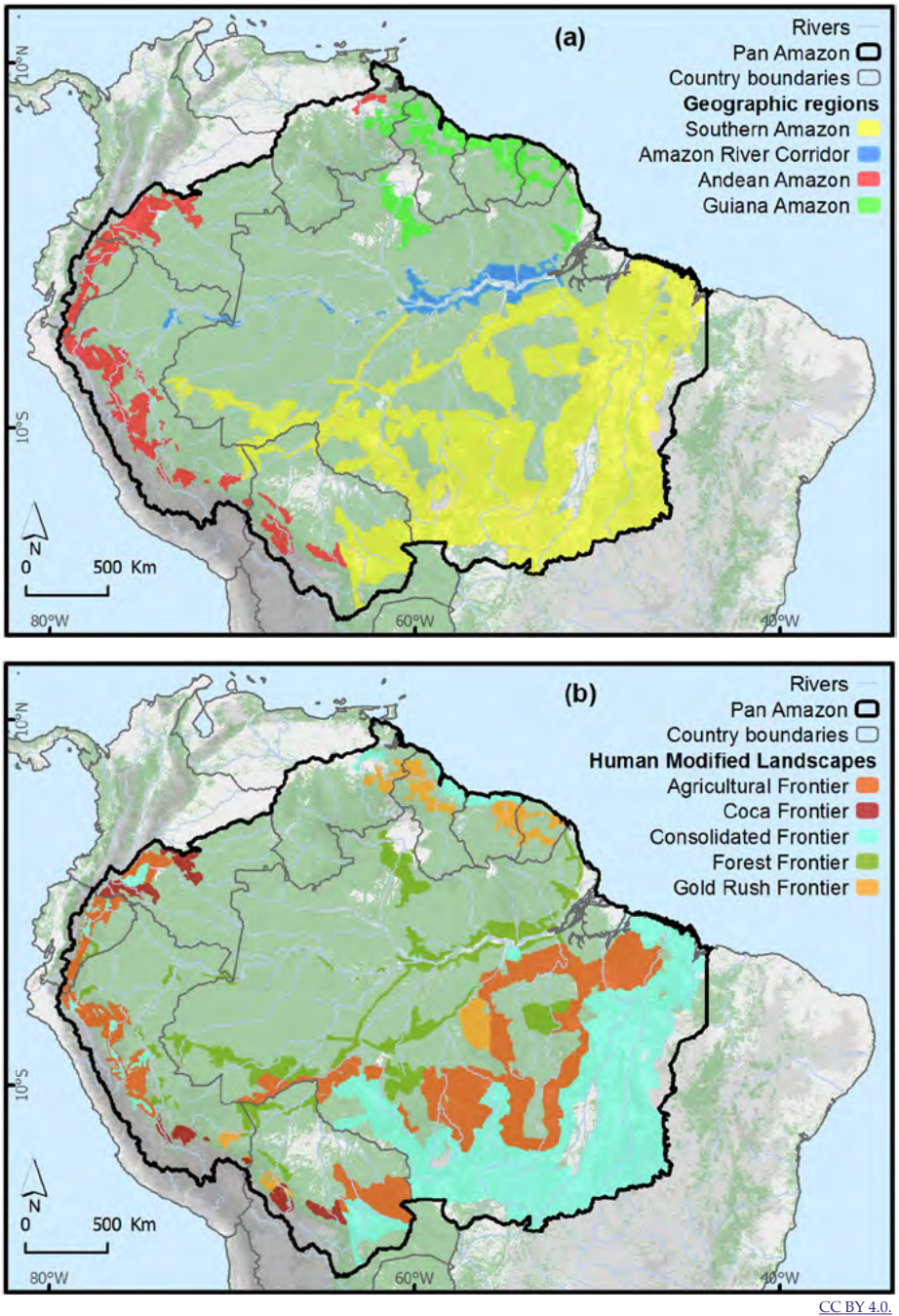

Figure 1.2: The human-modified landscapes of the Pan Amazon can be stratified according to geographic regions (a) and level of economic development (b).

landscape mosaics that include an approximately equivalent area of fragmented forest, both of which are surrounded by extensive areas of degraded forest damaged by illegal logging, wildfire, and overhunting. A conservative estimate of the total area of all these 'human-modified landscapes' is approximately 250 million hectares, which represents about thirty per cent of the geographic area of the Pan Amazon (Figure 1.2).

The human-modified landscapes of the Amazon can be stratified into four macro-regions, based on biophysical and cultural attributes that have determined their recent development. Each landscape has a unique development trajectory, but there are identifiable stages that reflect levels of infrastructure investment, agricultural production system, levels of technology, and social capital (see Text Box 1.1 and Figure 1.3).

Amazon River corridor

The upland terraces that flank the main stem of the Amazon River* are the oldest human-modified landscapes in the Pan Amazon. People have occupied these lands for millennia,† but their ethnic composition has changed over time as immigrants and escaped slaves intermarried with indigenous people to forge unique cultural groups referred to as *cabloco* (Brazil) or *ribereños* (Peru) (Chapter 6). The river connects rural communities with about two dozen small towns and six major urban centres: Belem, Macapá, Santarem, Manaus, Tabatinga, Leticia (Colombia), and Iquitos (Peru). The most densely populated stretch of the river is located between the top of the delta and Manaus, but isolated communities extend upstream to the junction of the Ucayali and Marañon rivers in Eastern Peru.

The foundation of the rural economy is based on the wild fish catch and non-timber forest products, particularly the super-fruit *açaí*, a palm that dominates floodplain habitats of the lower Amazon (Chapter 8). Most families cultivate a garden plot as part of their subsistence economy, while a limited number of secondary roads provide access to forest resources beyond the immediate confines of the river corridor. As a waterway, the river functions as a bulk transport system for bauxite mines located on upland landscapes adjacent to the floodplain (Chapter 5), as well as for commodities trans-shipped at ports that service the agricultural industry of the Southern Amazon (Chapter 2). Fluvial transport also serves the oil and gas sector while providing cost-effective transport for timber harvested

* Brazilians divide the Amazon into two sections: The name 'Amazon' is used for the section below the junction of the Solimoes and Rio Negro at Manaus; upstream they refer to the river as the 'Solimões', which extends to the junction of the Marañon and Ucayali rivers in Peru. Peruvians refer to the Solimões as the Río Amazonas.

† There is abundant archaeological evidence in the form of black earth soils documenting the extent of Pre-Colombian societies (Ch. 6).

from remote regions accessed by dozens of tributaries. Manaus is a travel destination marketed as the gateway to the Amazon, while Leticia and Iquitos have developed nature and cultural tourism linked to the domestic and international markets (Chapter 8).

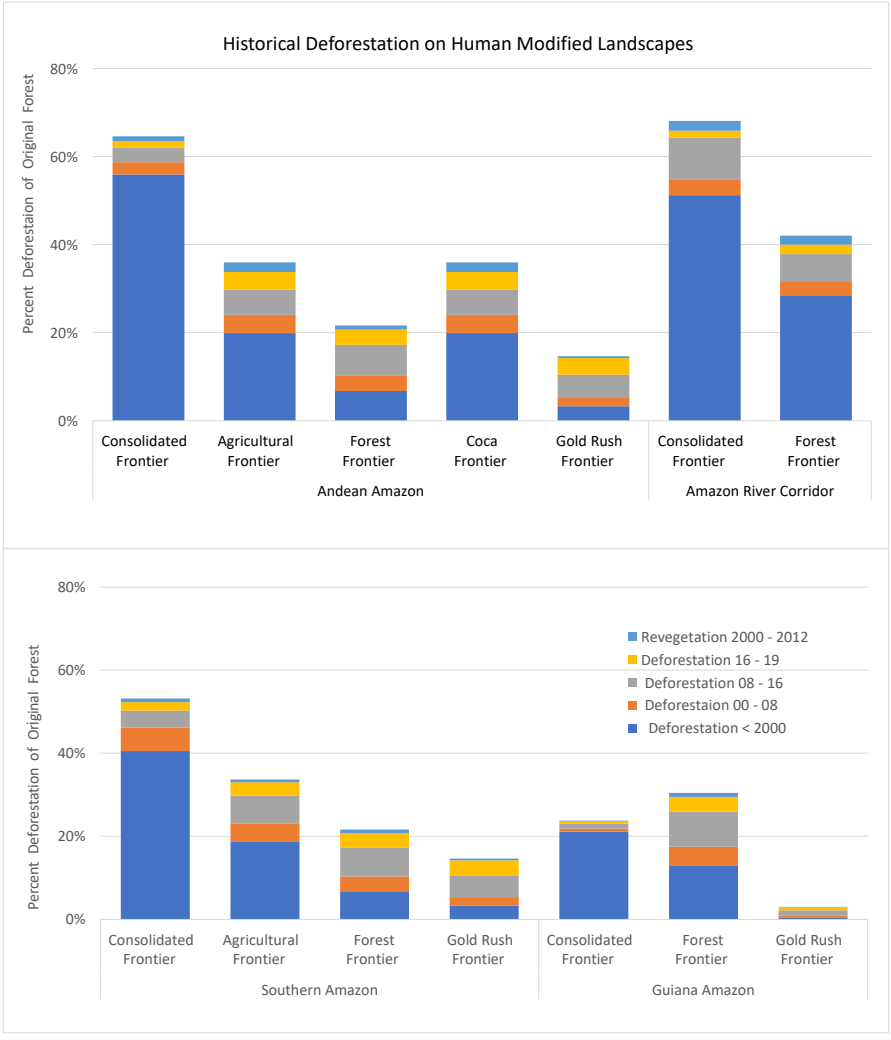

Figure 1.3: The human-modified landscapes of the Pan Amazon have different deforestation histories depending upon the phase of their development.

Source of land-use change data: Global Land Analysis and Discovery (GLAD).

The natural habitats of the Amazon River Corridor are remarkably well conserved, particularly above Manaus, where a wilderness riverscape extends more than 2,000 kilometres. Near Manaus, both sides of the river have evolved into forest frontiers, while the upland landscape between Oriximiná and Prainha in northern Pará has been deforested by the small farms and ranches established in the late 1960s and 1970s (Figure 1.2). Across the river in Santarem, grain silos and port facilities at the terminus of BR-163 are driving the conversion of pasture into cropland, which has caused this landscape in the heart of the Amazon to transition into an agricultural frontier dominated by the cultivation of soy.

Southern Amazon

The national development strategies epitomised by a highway network carved out of forest wilderness in the 1970s and 1980s set in motion a development trajectory that caused this region to be known as the Arc of Deforestation (Chapters 2 and 6). More than seventy million hectares of tropical forests have been sacrificed to create an agricultural economy that stretches from Eastern Pará, Brazil to Santa Cruz, Bolivia.

Low rates of deforestation within forest frontiers are a function of their remoteness and the poor state of their transportation infrastructure; landscapes closer to markets have transitioned into agricultural or consolidated frontiers. Rapid development has occurred on landscapes deemed to be geopolitically important (Rondônia) or where the soils were particularly apt for field crops (Mato Grosso and Santa Cruz). Public lands have been distributed to more than a million pioneer families and several thousand private companies via a variety of legal and extra-legal mechanisms (Chapter 6). The resulting land tenure mosaic reflects both the diversity of landholdings (small, medium, large, and massive), as well as the ongoing appropriation of state lands that continues to drive deforestation on forest frontiers (Chapter 4).

Most smallholders dedicate a portion of their land to produce basic foodstuffs, but the production of beef cattle is the major driver of deforestation on both forest and agricultural frontiers (Chapter 3). The global demand for soy in the 1990s stimulated the expansion of agribusiness and enabled business models dependent upon overseas export markets. The cultivation of maize in rotation with soy catalysed the explosive growth of the poultry and swine sectors, while the cultivation of oil palm diversified the rural economy in Northeast Pará (Chapter 3). Global competition is driving investment in bulk transport systems that link the production landscapes of the Southern Amazon to the grain terminals on the Amazon River (Chapter 2).

The cultivation of field crops is the preferred production strategy where topography and soils permit allow farmers to harvest two crops per year. The soy-maize production model contributed $US 25 billion to the Mato Grosso economy in 2020. Corporate farms predominate on some landscapes (a), but they share the export market with thousands of family farms. All rely on logistical infrastructure, such as these silos on BR-163 highway (b), which connects to global markets via ports on the Amazon River.

The development strategies of the 1970s included programmes for the exploitation of the region's mineral resources. Its recent history has been marked by chaotic gold rushes that ebb and flow with the price of gold (Chapter 5). More long-lasting development has resulted from the exploitation of world-class deposits of industrial metals at the Serra de Carajás in Pará, which stimulated investments in railroads, industrial mills and hydropower facilities. Infrastructure development represents a significant part of the regional economy, in part because the Brazilian government has built more than fifty hydropower facilities in the region, including several mega-scale facilities (> 1,000 MW) on the Madeira, Tocantins and Xingu rivers (Chapter 2).

The Southern Amazon can be stratified into five forest frontiers, eight agricultural frontiers, five consolidated frontiers and one active gold-rush frontier (Figure 1.3). If current trends continue, the forest frontiers will transition into agricultural frontiers and agricultural frontiers into consolidated frontiers. These human-modified landscapes, which are organized around a network of trunk highways, are separated by forest remnants that are increasingly isolated from each other and from the continuous forest landscapes of the West, Central, and Northern Amazon.

Andean Amazon

The cultural traditions and the national development strategies pursued by the Andean republics created human-modified landscapes that are fundamentally different from the Southern Amazon. Each country built a series of individual highways that connect a specific sector of the Andean highlands with an adjacent region of the Amazon lowlands. All roads traverse the Andean foothills, where tens of thousands of settlers established homesteads on steep slopes inappropriate for agriculture (Chapter 2). Soil erosion limits the productive capacity of farmsteads while threatening the integrity of the roads built on landscapes with extraordinarily high levels of rainfall.

Colonisation has been driven by migration from indigenous highland communities who have laid claim to small landholdings using forest-fallow production systems to produce basic foodstuffs for domestic markets (Chapter 6). Over time, settlers have diversified their production systems to include oil palm, coffee and cacao, some of which is destined for overseas markets. Pastures are abundant, and many families own cattle; however, the beef industry is not a driver of deforestation but an artefact of the forest-fallow production system. On selected landscapes, farmers cultivate coca leaf, sometimes legally for domestic consumption but more often as an illicit crop for the global cocaine market. A limited number of corporations

Deforestation in the Andean foothills is particularly damaging due to high rainfall and soil erosion on steep slopes that limits the productive life span of cleared fields; settlers tend to be small farmers producing basic foodstuffs for the domestic market.

have invested in large-scale oil palm plantations and associated industrial facilities in Peru and Ecuador (Chapter 3).

The mineral wealth of the region is concentrated in the High Andes, where global corporations operate industrial mines in polymetallic ore bodies that have been exploited for centuries. Gold that originated from these geological formations has been transported to the alluvial sediments on the piedmont that are exploited by small-scale miners in selected landscapes experiencing a gold rush. The Western Amazon has significant oil and gas reserves located beneath the alluvial landscapes east of the Andes, and the revenues derived from their exploitation have been a pillar of national economies and state budgets since the 1960s (Chapter 5).

Investment in infrastructure has accelerated in the last two decades thanks to an international effort to coordinate national development strategies and promote economic integration among countries via the Initiative for the Integration of the Regional Infrastructure of South America (IIRSA). Among the highest IIRSA priorities have been transportation corridors that transect wilderness landscapes, linking the Pacific Coast with the Amazon River and the agricultural landscapes of the Southern Amazon. The massive elevational drop in rivers that originate in the Andes has favoured the development of dozens of medium- and large-scale hydropower facilities. With one notable exception, efforts to promote mega-dams have not been successful because the proposed investments have not withstood financial due diligence (Chapter 2).

The human-modified landscapes of the Andean Amazon include four forest frontiers and six agricultural frontiers, seven coca frontiers and

two gold-rush frontiers (Figure 1.3). Migration and forest loss occur altitudinally, as agricultural frontiers expand upslope, and laterally, as pioneers settle adjacent valleys or emerge onto nearby lowland landscapes. Unlike the Southern Amazon, where forest frontiers are associated with roads, the most dynamic forest frontiers in the Andes occur along river corridors (Chapter 6). Individual lowland landscapes have remained isolated from each other for decades; only Ecuador has built a road that connects all of the lowland settlement zones with an integrated trunk highway. The decision (or delay in deciding) to integrate settlement zones along the piedmont has maintained a limited number of biological corridors that connect the lowland forests of the Western Amazon and the montane forests of the Andean foothills (Figure 1.2a).

Guianan Amazon

The human-modified landscapes of the Guiana Shield have avoided the settlement and colonisation phenomena that caused the widespread deforestation in the Southern Amazon and Andean Amazon. Historical settlements are clustered along the coast of Guyana, Suriname and French Guiana, while Venezuela has pursued a national development strategy based on petroleum development and urbanisation (Chapter 6). Only the Brazilian state of Roraima was the target of resettlement schemes in the 1970s when a paved highway was built to connect Manaus with Boa Vista and, eventually, with the Venezuelan and Guyana national road networks. Currently, Brazil is building a modern highway in Amapá to connect the Amazon port city of Macapá with the development corridor of the Guiana Coast (Chapter 2).

Suriname and Guyana were once major producers of bauxite, but those mines have shut down after exhausting the easily exploitable deposits, leaving behind degraded landscapes and toxic tailing ponds. Northern Pará and Amapá have significant reserves of ferrous minerals, copper and gold, but most are located within a strategic mineral reserve that is closed temporarily to exploitation (Chapter 5). Venezuela has economically attractive bauxite deposits and world-class reserves of iron ore; nonetheless, its industrial mines and processing facilities are operating at minimal levels due to economic mismanagement.

The very considerable gold resources of the Guianan Amazon are associated with a geological formation known as a greenstone belt that has sustained a decades-long gold rush by small-scale miners, including native-born maroons and temporary migrants from Brazil. Most of the deforestation in the Guianan Amazon is caused by these miners; consequently, it is dispersed across landscapes as small patches that are difficult to detect using commonly available satellite images. Periodic gold rushes

have occurred in Bolivar state in Venezuela and along the border with the Brazilian state of Roraima. Large-scale corporate gold mines are operating or under development in Guyana, Suriname, French Guiana, and Amapá (Chapter 5).

The human-modified landscapes of the Guiana Shield include two gold-rush frontiers, two forest frontiers and two consolidated frontiers. The recent discovery of large reserves of oil and gas offshore from Guyana and Suriname will transform their economies over the short term.

Hydrological degradation

The Amazon River system is the world's largest freshwater ecosystem, with nearly twenty per cent of the Earth's freshwater discharge. It is a megadiverse aquatic biome and an enormously productive ecosystem that provides livelihoods and essential protein resources for its resident populations. It is also a strategic economic asset due to its hydropower capacity and as a waterway in a region that lacks roads (Chapter 2). The massive volume of water that flows through the Amazon River system provides an inherent level of resiliency, which is augmented by intact floodplain habitats that buffer seasonal fluctuations in waterflow and absorb the effluents of human society. Nonetheless, development phenomena have impacted the rivers and streams within human-modified landscapes.

Illegal gold mining has impacted the biogeochemistry of the rivers that drain the gold-rush landscapes where small-scale gold miners are active (Figure 1.2b). The spatial footprint from individual mining operations is [relatively] small, but the environmental impact is magnified by the tendency of miners to operate within floodplains. The widespread use of mercury, a heavy metal with well-documented deleterious effects on human health, is creating an environmental legacy that will plague the region for decades (Chapter 5). Virtually all small-scale miners violate environmental laws and evade taxes; many are guilty of human rights violations (Chapter 7). Illegal gold mining is likely to increase over the near term due to the volatility of financial markets, which motivates global investors to buy gold as a hedge against uncertainty.

Dams and reservoirs cause permanent and long-term impacts by modifying hydraulic regimes, capturing sediment, and interrupting fish migration (Figure 1.4). Multilateral financial agencies have provided key financing to both public and private entities; companies from China have acquired distressed hydropower assets in Peru and Brazil while providing turn-key solutions to Bolivia and Ecuador. All the Pan Amazon nations have pursued hydropower development as part of their national energy strategies, and Brazil is leveraging the construction of hydropower projects to develop waterways as bulk transport systems.

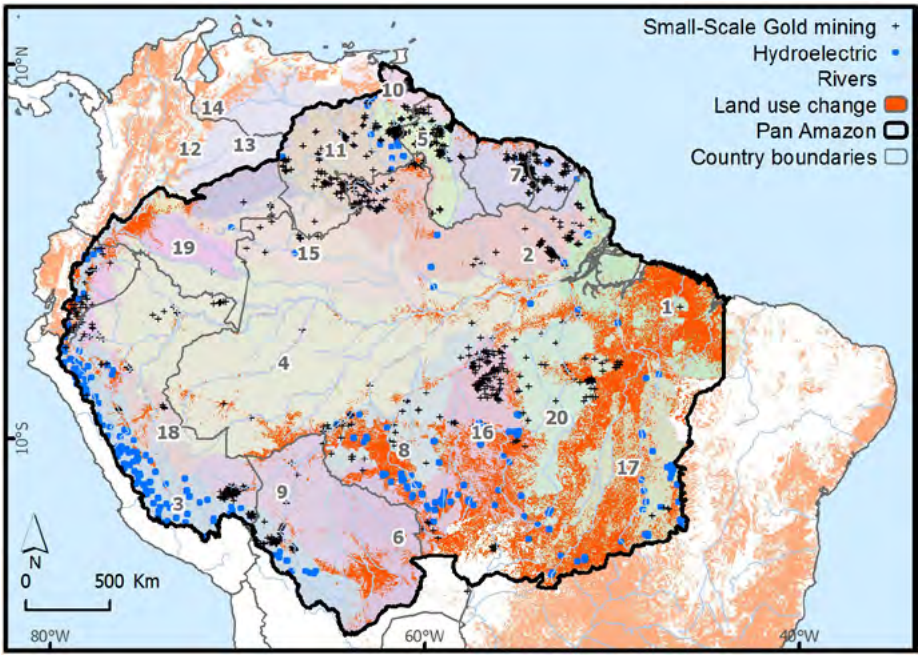

Figure 1.4: There are three major sources of hydrological degradation: (1) dams that trap sediments, interrupt hydraulic cycles and block fish migration (blue box); (2) illegal gold mines that destroy floodplains and release mercury (black x); and (3) run-off from land-use change (red areas). The coloured polygons are 'hydrosheds', which stratify river basins based on biogeochemical attributes.[26]

Sources: gold mine landscapes – Google Earth & RAISG (*Rede Amazônica de Informação Socioambiental Georreferenciada*); dams – RAISG; Hydrosheds – B. Lehner and G. Grill. 2013. *Hydrological Processes* **27** (15): 2171–2186; Land cover data – ESA. Land Cover CCI Product User Guide Version 2. Tech. Rep. 2017.

Land-use change and agricultural runoff have impacted the geochemistry of most of the headwaters of the rivers of the Southern Amazon, where the conversion of ~50% of the original forest cover has increased sediment loads and altered the nutrient status of the region's unique 'clear-water' rivers. These impacts should be mitigated by environmental regulations that obligate landholders to conserve forest in riparian corridors; however, noncompliance is widespread, and efforts to motivate landholders to reforest riparian corridors are constrained by cost and apathy (Chapter 7). Deforestation has impacted precipitation regimes, which will decrease runoff volumes, a phenomenon that will become greater over time as farmers adopt irrigation technology to mitigate the threat of seasonal drought (Chapter 4).

The Political Economy of the Pan Amazon

Politics is idiosyncratic to each country, but trends in economic policies span borders. The political economy of the Pan Amazon is the legacy of strategic development plans that began in the mid decades of the twentieth century when the Amazonian nations turned their attention to the development of the Amazon (Chapter 6).

The nationalist period (1960–1985) was characterised by authoritarian governments that sought to use the power of the state to harness the natural resources of the Amazon. The push into the region was seen as a way to generate economic growth, mitigate poverty and avoid political unrest driven by socialist ideology. Governments were insensitive to environmental and cultural impacts and viewed the Amazon as an unpopulated region that could absorb a growing population. Highways were extended into the wilderness, and public lands were distributed to landless peasants and corporate investors. Mining ventures and oil exploitation were subsidised by the state. Development was synonymous with deforestation.

The neoliberal period (1985–2005) began with a wave of market-oriented reforms designed to foster economic growth via the private sector. Referred to as the 'Washington Consensus', each country enacted a suite of policies to privatise state-owned entities, eliminate budget deficits, reinforce property rights, promote free trade and facilitate foreign investment. The state's role was to provide essential services, such as law enforcement and the administration of a streamlined regulatory apparatus. The Amazon was integrated into an increasingly globalised economy; meanwhile, environmental and social advocates drew attention to the magnitude of deforestation and the plight of indigenous communities. The concept of sustainable development emerged from academia and soon dominated policy forums. Commodity exports were synonymous with development.

The populist period (2005–2019) was a reaction to the austerity associated with neoliberal policies and a cultural aversion to foreign influence. Governments enjoyed robust electoral majorities by promising to address social inequality while embracing a form of democratic socialism that enhanced the role of the state in the national economy. Unlike previous socialist movements, however, these governments protected private sector actors who were generating the economic growth and export revenues essential for financing their political agendas.* Like their neoliberal precursors, populist governments made public commitments to sustainability, supported conservation initiatives and acted to protect the rights of indigenous communities, all while investing in infrastructure and conventional development paradigms. Sustainability was a synonym for the *status quo*.

* An exception to this was the government of Venezuela, which has pursued an extreme form of socialism combined with authoritarian rule.

Each of these phases created 'facts on the ground' that would constrain or enhance development and conservation options in subsequent decades. For example, the trunk roads carved out of the forest between 1970 and 1980 created the framework for future highway investments that are a recurrent feature in the annual budget of the Brazilian state. The development of oil and gas fields in the Andean republics during the 1960s now generates revenue streams essential for macroeconomic stability while creating infrastructure assets, such as pipelines, that are used to expand operations into wilderness landscapes (Chapter 5). The export-driven agribusiness production model consolidated during the late 1990s is now an indispensable component of the national economy and has endowed agribusiness with the financial capacity to invest in bulk transport systems (Chapter 2). The beef industry in Brazil and Bolivia has tens of thousands of constituents with sufficient political power to allow them to ignore land-use regulations intended to slow deforestation (Chapter 7). The creation of protected areas and the recognition of the territorial rights of indigenous people removed almost fifty per cent of the surface area of the Amazon from the reach of conventional development (Chapter 10).

The political nature of the next period is uncertain. In 2019, Jair Bolsonaro was elected president of Brazil with an avowed agenda of reversing the conservation policies of the past two decades and returning to the unbridled development that characterised the 1970s. In the Andean republics, there is widespread dissatisfaction with political elites tainted by corruption, but newly elected governments continue to pursue conventional development models, tolerating deforestation and the destruction of aquatic ecosystems caused by small-scale gold miners. Venezuela is a basket case, while the republics of the Guyana Coast are in the process of embracing an economy reliant on fossil fuels.

Understanding the conventional economy

The economies of nations are traditionally evaluated by their gross domestic product (GDP), a metric that measures the total economic output of a nation. The GDP of the Pan Amazon was approximately $US 270 billion in 2017 (Figure 1.5),* a modest number in a global economy valued at $US 80 trillion in the same year. By way of comparison, this is approximately equal to the total income of the online retail company that has appropriated the

* This value was compiled from reports published by national statistical agencies that stratify information by sub-national jurisdiction and sub-sector; Guyana and Suriname report only national data; Venezuela does not report GDP data stratified by region and is excluded. The GDP metric reported here is based on 'current value' and compared among jurisdictions using mean annual exchange rates in 2017.

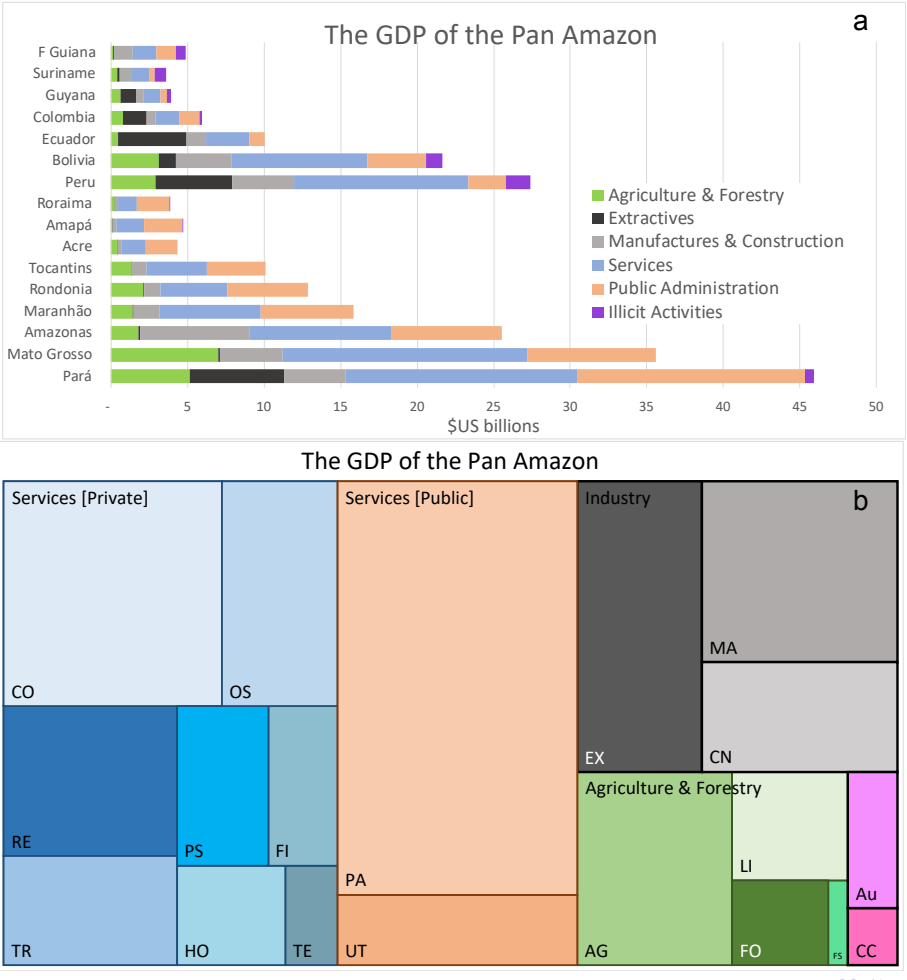

Figure 1.5: The GDP of the Pan Amazon stratified by political jurisdiction and sector (a) and subsector (b). Agriculture & Forestry: Agriculture (AG), Fisheries & Aquaculture (FI), Forestry (FO), Livestock (LI); Industry: Extractives (EX), Manufacturing (MA), Construction (CN); Services (Private Sector): Real Estate (RE), Commerce (CO), Transportation (TR), Hospitality (HO), Telecommunications (TE), Finance (FI), Professional Services (PS), Other services (OS); Services (Public Sector): Public Administration (PA), Utilities (UT); Illicit Activities: Coca/Cocaine (CC), Artisanal Gold (Au).[27]

name of the world's largest tropical forest.* The contribution to national GDP from the jurisdictions located within the Pan Amazon range from a high of 100% (Guyana and Suriname) to a low of 0.2% (French Guiana). The contribution of Amazonian regions to national GDP is small but significant in Brazil (8%), Peru (13%) and Ecuador (10%), less in Colombia (2%), and considerably more in Bolivia (59%), where three major urban centres lie within the Amazon basin.†

There are numerous problems with using GDP as an analytical metric (see below); nonetheless, it is the most commonly used statistic for evaluating the economy of a nation. The first priority of most governments is to promote economic growth, and their motivation is as simple as it is obvious: an increase in GDP reflects increased wealth, which can be used to reduce poverty; a decrease connotes a recession, which usually means an increase in poverty. Governments, and their advisors in multilateral development institutions, use GDP and its underlying metrics to identify how fiscal policies, such as taxes, subsidies and public investment impact the conventional economy. GDP is particularly informative when it is disaggregated into component metrics that measure economic production for economic [sub] sectors and organised by subnational jurisdiction (see Annexes 1.1 and 1.2).

The GDP metric has limited utility when evaluating the economic health of a society.[7] Its detractors point out five major limitations, all of which are germane to the Amazon: (1) it provides no information on inequality; (2) it underestimates the contribution of the informal sector;‡ (3) it makes no attempt to measure the economic value of subsistence activities; (4) it does not distinguish between sustainable activities, such as the harvest of renewable resources, and non-sustainable business models, such as the exploitation of non-renewable resources; (5) it fails to account for negative outcomes that create a long-term economic liability, such as an oil spill§ or the loss of a key ecosystem service. In spite of these limitations, or because they are so obvious, a review of the conventional economy using GDP metrics highlights the challenges and opportunities facing the pursuit of a sustainable economy.

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* Amazon.com reported $US 233 billion in total sales in 2018 with an annual growth rate of ~30%; in contrast, GDP for the Pan Amazon increased by about 2% between 2017 and 2018.

† Santa Cruz, La Paz and Cochabamba together comprise about 55% of the population.

‡ When lacking data, economists estimate metrics using models based on (i) differences in expenditures and income or (ii) currency demand, or (iii) by tracking the consumption of a commodity correlated with economic activity such as electricity; source: Federal Reserve Bank of St. Louis.

§ Ironically, expenditures to remediate an oil spill will register as a positive contribution to GDP.

Perhaps the most revealing number in the sectoral GDP statistics is the minuscule contribution of the forest sector (< 2%), a paltry sum when considering the intrinsic value* of the Amazon's vast renewable natural resources (Figure 1.5). The most obvious explanation for this low number is the failure to assign value to subsistence activities. Indigenous people and traditional communities harvest food and fibre from natural ecosystems; most forest families grow food for their own consumption. These activities have tangible economic value and are central to the livelihoods of forest families, but they are ignored by measurements of GDP. Additionally, most households complement subsistence activities by harvesting timber, non-timber forest products and wildlife. Some of this production is captured by the statistics, particularly for the commercialisation of forest goods with strong export markets, such as Brazil nuts and palm fruits; however, other valuable products, such as timber and fish, are sold to middlemen who operate within the informal sector of the domestic economy (Chapter 8). Nonetheless, if the real contribution of the forest economy was twice the value of the official statistics, it would still lag the sectors of the economy driving deforestation and other forms of environmental degradation. The low valuation of forest products shines a spotlight on the challenge of using the forest economy as an alternative development strategy to displace agriculture and livestock.

The informal economy in Latin American nations accounts for approximately thirty per cent of total economic activity;[8] that proportion is greater in frontier communities, where 'cash is king' and the institutions of the state are weak or absent. This is even more true for smallholder landscapes where subsistence farming is combined with the cultivation of foodstuffs commercialised in domestic markets (Chapter 3). Approximately ten per cent of the previously deforested lands in Brazil and Bolivia have been settled by small farmers; although their spatial footprint is limited, they constitute about seventy per cent of rural families and are an important source of basic foodstuffs, such as manioc, rice, beans and a variety of tropical fruits.[9]

In Peru and Ecuador, the predominance of smallholders is much greater, representing about 98 per cent of all landholdings and occupying more than ninety per cent of agricultural landscapes (Chapter 4). The production model pursued by the majority of smallholders on frontier

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* Investors use the term intrinsic value to describe the potential value of an asset based on an objective evaluation that considers the long-term potential return; it is used in juxtaposition to the term market value, which reflects the earnings generated by the asset. Philosophers and environmental economists use intrinsic value to describe a point of view that resists efforts to ascribe a monetary value to nature, arguing that it has value in and of itself. Both usages are valid for the Amazon.

Coffee cultivation can be a driver of deforestation when new fields are established by clearing natural forest, or a sustainable form of tropical agriculture if producers expand by recovering abandoned fields and secondary forest. Photograph from Ecuador.

landscape is based on slash-and-burn technology, which is used to establish and maintain a forest-fallow production system. Most farmers invest in perennial production systems over time as they diversify their crops and plantations, but they expand cultivation at the expense of remnant forests within their properties. The full value of their production is not incorporated into GDP, which causes the official statistics to underestimate their contribution to the regional economy, as well as the economic forces that drive deforestation by smallholders.

A more significant factor in the underappreciation of agriculture and livestock production is the methodological framework designed to avoid double accounting when compiling the GDP metric. Unlike the underreporting caused by the informal economy or subsistence farmers, this is not a bug (flaw) but a feature of the GDP bookkeeping methodology. The value of the production for any sector is measured only once, and in the case of agriculture, that data is captured at the 'farmgate' a term used to describe the price paid to the producer. All subsequent transactions 'add value' to the commodity and are accrued to a supply chain participant; for

example, the increased value of dressed beef and soy oil are accrued to the manufacturing sector, while the cost of hauling grains to export terminals is allocated to the transportation sector. Similarly, expenditures for inputs made by farmers and ranchers prior to the harvest or the sale of livestock are subtracted from farmgate revenues and assigned to their respective service sectors, which includes veterinarians, seed companies, appliance dealers, fuel companies, and agrochemical venders. A comparison of the total gross value of farm production in Mato Grosso compared to the value-added metric used to compile sectoral GDP reveals that 45 per cent of the total proceeds are allocated to service providers or manufacturers in the commodity supply chain.[10]

The service sector is the largest component of GDP in seven jurisdictions and the second most important sector in the remaining ten (see Annexes 1.1 and 1.2). The predominance of the service sector is not uncommon among nations because it is a basket of many different economic activities. The growth of the service sector is also the consequence of the ongoing urbanisation of Amazonian society (Chapter 6). More than fifty per cent of the region's inhabitants reside in cities with populations greater than 100,000, and the overwhelming majority work in the service sector. Many of the services in large cities are environmentally benign and could be easily accommodated within a 'green' economy, including telecommunications, information management, health care, hospitality, and finance. Only Manaus has a strong manufacturing sector, an anomalous situation maintained by subsidies and tariff barriers. The other large cities (Belem, Santa Cruz, Cuiabá, Santarem, Porto Velho) are economically diverse, but their manufacturing and service companies rely directly or indirectly on revenues from the extractive industry or the agricultural and livestock sectors. The dependence of mid-sized cities (10,000 to 100,000 residents) on the rural economy is even more pronounced because they are the economic gateway for private sector services to farms, ranches and rural communities.

Mid-size cities and towns are also where rural inhabitants access public services, most importantly health care and secondary education, but also technical assistance and financial credit. The poor quality of rural schools motivates many families to maintain a residence in nearby small towns, one of several factors contributing to rural-urban migration. Urban inhabitants also enjoy access to basic services taken for granted in advanced economies, including sanitation, electricity, access to the internet and higher education. All of these are absent in the rural Amazon. Government expenditures are relatively large in Brazil and are the leading sector in Acre, Amapá, Rondônia and Roraima (see Annex 1.2), which reflects that nation's willingness to subsidise its frontier jurisdictions via revenue transfers from federal to state and local budgets. This includes operating budgets for law enforcement and agricultural research and extension, as well as support

for a large public university system (Chapter 9), environmental oversight (Chapter 7) and management of protected areas (Chapter 11).

Brazil's generosity contrasts with the nations of the Andes, where small public budgets in Amazonian jurisdictions are a legacy of their centralised governance systems (Chapter 7). The somewhat greater contribution in Bolivia is due to the inclusion of its capital city (La Paz) within the Pan Amazon, while Colombia's is the consequence of the budget allocated to its security forces (Chapter 6 and 7). Guyana and Suriname have budgets that were historically similar to the Andean republics, but public expenditures will surge after 2021, when offshore oil fields start producing oil and natural gas (Chapter 5).

Public budgets provide one of the easiest avenues for channeling financial resources to shift the Amazonian economy away from non-sustainable production paradigms, which is why the jurisdictional approach is gaining popularity as a way to organise the payment-for-ecosystem services.* The challenge will be to translate an increase in state expenditures into a modification of behaviour by private sector actors. Brazil pursued a version of this strategy from 2004 to 2018 when it successfully reduced deforestation within its Amazonian states by eighty per cent (Chapter 10); however, this effort has caused a political backlash by landowners opposed to the regulatory measures imposed by the state.

All the Pan Amazonian nations suffer from a deficit in basic infrastructure, a consequence of decades of underinvestment caused by political instability, poor governance and financial austerity imposed by multilateral financial institutions.[11] A surge in construction activity occurred between 2005 and 2015 when the global commodity boom provided national governments with revenues that allowed them to radically increase investments in basic infrastructure (Chapter 2). Urban areas benefited most because that was where the need was greatest; however, investments in transportation networks and energy systems were a priority as governments sought to increase economic growth by integrating frontier landscapes into the national economy and harnessing the natural resources of the Amazon.

The contribution of the construction industry to regional GDP is large across all jurisdictions, placing just behind agriculture as a component of the conventional economy (see Figure 1.6). Financing for infrastructure comes from a combination of annual budgets, debt issued from national development banks, government-backed bonds and multilateral development agencies. State-backed entities from China have become a prominent participant in large-scale hydropower projects, while private investors have assumed a leading role in the development of railroads (Chapter 2).

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* See the section below, 'Monetising the Value of Ecosystem Services – or Not' on page 55.

Large-scale construction projects in Amazonian jurisdictions have been harshly criticised for their environmental and social impacts (Chapter 7); nonetheless, they enjoy the support of elected officials from successive governments. The construction sector is an unabashed proponent of investment in transportation and energy infrastructure and views deforestation and hydrological degradation as acceptable environmental impacts.

There is an inherent synergy between expenditures in construction and the value of real estate. Investments add value to an asset, while property values increase following improvements in public infrastructure. The reported contribution of real estate transactions to GDP is approximately the same as that of construction and, likewise, is largely the consequence of investments in urban centres. The declared value of real estate transactions, however, is often under-reported by buyers and sellers in order to evade taxes, a practice more prevalent on frontier landscapes where contracts are executed without the intermediation of banks (Chapter 4).* This common practice is another example of how the informal economy gives rise to corrupt practices, and its contribution to GDP is underestimated. Real estate markets are further distorted by the highly lucrative activity of land grabbing and, in the Andean republics, money laundering linked to illicit drugs (Chapter 3). Reining in land grabbing is impeded by the agencies that administer titles, which are plagued by administrative inefficiencies, a backlog of work spanning decades and functionaries complicit in criminal activity (Chapter 4).

The extractive industries in Pan Amazonian jurisdictions are massively important for the national economies of Colombia, Ecuador, Peru, Guyana, Suriname and, to a slightly lesser extent, Bolivia and the state of Pará (Annexes 1.1 and 1.2). All mineral resources in the Pan Amazon are the property of the state, which exploits them via a state-owned enterprise or some type of joint venture with corporations that specialise in mining or the production of hydrocarbons (Chapter 5). Revenues accrue to a region's GDP, even though they do not flow through the local economy; instead, they are deposited directly into the national treasury. This bookkeeping procedure distorts the value of the GDP-per-capita, which is often [mis-] reported by the mass media as a measure of human wellbeing. Forty-five per cent of GDP in Amazonian Ecuador is contributed by oil exports and, if you exclude that revenue from the regional GDP, the per capita value in 2017 would fall from US$ 11,500 to US$ 6,400.

Governments return mineral rents to producing regions as royalties that are included within GDP values reported for public administration.

* In Bolivia, transactions are actually formalised with two sets of parallel documents: one with the real value, which is kept private, and one with a 'cadastral' value, which is reported to the authorities. In spite of an obvious fraud, courts will accept the real value version in litigation.

The Trans Andean oil pipeline in Ecuador has caused numerous oil spills during its 40-year life span; the right-of-way is used by locals to access small farms cleared from the forest. Petroleum production is an important source of government revenues.

Royalties vary among jurisdictions and across commodities: Peru has the most generous revenue sharing mechanism, which combines royalties with corporate income tax in a system referred to as a Canon. Brazil has the most frugal royalty system but transfers a larger sum of money via the general budgetary system (Chapter 5). Like agriculture, the extractive industries generate benefits to regions via the service sector, which vary depending upon the mineral commodity: hydrocarbons pay higher royalties but consume fewer services, while miners pay lower royalties but consume more services.* In Ecuador and Colombia, the exploitation of petroleum was a major driver of Amazonian settlement and deforestation, while the development of the iron ore deposits in the Carajás highlands was part of a multi-sectoral development strategy (see Text Box 1.2).[12]

The mining sector has an illegal component that is one of the most lucrative activities in the Pan Amazon. Artisanal and small-scale gold mining generated an estimated seven billion dollars in 2017, of which about half was exported via channels invisible to authorities. Most small-scale miners use placer mining technologies that destroy floodplains while polluting watersheds with mercury. The most seriously impacted basins are the tributaries to Madeira (Madre de Dios and Beni) and Tapajós (Crepori), the Caroni River in Venezuela, the Essequibo in Guyana and the Courantyne on the border between Suriname and French Guiana (Chapter 5).

* In Ecuador, value added GDP was 50% of the gross oil production, while in Pará, value added GDP was 40% of gross revenues. Since production costs are fixed, these percentages vary depending on the price of these global commodities. Source: *Instituto Brasileiro de Geografia e Estatistica (IBGE) and Dirección Nacional de Síntesis Macroeconómica, Banco Central de Ecuador.*

Text Box 1.2: The Carajás – São Luis Development Corridor

Pará has developed a metallurgical industry, the result of a deliberate national strategy to add value to mineral exports; this has led to investment in industrial mills that transform bauxite into aluminum and iron ore into steel. Aluminum smelting is an energy-intensive process and that has motivated the construction of large-scale hydropower facilities on the Tocantins and Xingu Rivers. Steel mills and pig-iron foundries consume vast quantities of vegetable charcoal provided by landholders who established cattle ranches along the rail line between the mines at the Serra de Carajás and the port facilities near São Luis do Maranhão.

State governments in Pará have a tradition of being 'pro-mining', which reflects the economic benefits derived from the mines, including royalties and tax revenues, but more importantly from the economic growth spawned by the goods and services sold to the mining companies. The development corridor between the Serra de Carajás and São Luis do Maranhão has lost more than eighty per cent of its original forest cover.

Placer gold mines on a tributary to the Río Madre de Dios in Southern Peru; these strip-mines are particularly pernicious because their impacts extend far beyond deforestation of the mine site, which typically spans the entire floodplain from river terrace to river terrace for dozens of kilometers. Watersheds are polluted by mercury and sediments, while fish migration is impeded both above and below the mine site. This highly lucrative activity is pursued by small to medium-sized miners who operate outside law.

Another illegal activity not captured by GDP is the coca-cocaine supply chain that originates in Bolivia, Colombia and Peru. The quasi-legal (or tolerated) cultivation of coca is associated with blatantly illegal laboratories that process coca leaf into cocaine. The coca-cocaine supply chain generates about 1.5 billion dollars annually within Amazonian jurisdictions, an amount multiplied several times over as money is laundered in the commerce, construction and real estate sectors. Coca cultivation is an important source of deforestation in the Andean foothills, where it occurs on landscapes surrounding protected areas and indigenous territories (Chapters 3 and 10).

The Natural History of the Amazon Rainforest

In the nineteenth and first half of the twentieth centuries, scientists affiliated with institutions in the Northern Hemisphere organised most expeditions into the Amazon. These botanists, zoologists and anthropologists were accompanied by native-born and immigrant scientists who pioneered the establishment of natural history museums in the nations of the Pan Amazon. Investment in research and education expanded dramatically as governments pursued development strategies predicated on the exploitation of the region's natural resources. Institutional capacity grew to encompass more than fifty universities and a half dozen research institutions within the Pan Amazon. Collections, publications and students grew exponentially and, by the end of the millennium, more specimens were accessioned annually in the regional museums than all of the legacy collections housed in foreign museums (Chapter 9).

The collections in European and North American museums are the foundation of the taxonomic classification systems at the centre of biodiversity science; unfortunately, that information was unavailable to local biologists, who struggled to identify the plants and animals they encountered during their fieldwork. Starting in the 1980s and accelerating in the 1990s and 2000s, innovation in information management and the creation of the internet revolutionised biodiversity science. Online information resources, such as taxonomic databases and digital image archives, have vastly improved the quantity and quality of floristic and faunistic inventories. Every country can now boast a relatively complete catalogue of all vertebrate groups and a robust checklist of vascular plants, which continue to improve as cadres of young biologists explore their countries. Biogeographers and population ecologists can now accurately map the distribution and abundance of species, which has improved the identification of endemic species unique to a specific region or locality, as well as objectively evaluate the risk of

extinction for individual species.* Regional biologists routinely participate in the global effort sponsored by the International Union for Conservation of Nature (IUCN) to identify species at risk of extinction while leading the same effort within their own countries. Having these studies executed by native-born biologists laboring within domestic institutions has increased the legitimacy of that information in the eyes of government and society.

Forest ecology and carbon dynamics

A tropical rain forest is composed of thousands of species of long-lived trees, each with a natural history characterised by unique morphological, physiological and reproductive attributes. Very little was known about the ecological processes within these plant communities in 1980 when ecologists began to establish long-term studies to document their composition, structure and function. In one project near Manaus, scientists created an experiment to evaluate the impact of deforestation and forest fragmentation on plant and animal communities.† In another, dozens (eventually, hundreds) of botanists affiliated with local universities and research institutions created a network‡ of hundreds (eventually, thousands) of permanent one-hectare plots scattered across the entire region. They have used these plots to study Amazonian tree biodiversity, identifying which species are extraordinarily abundant (hyperdominant) and which are exceedingly rare, as well as documenting how tree communities vary across latitudinal, elevational and climatic gradients, information essential for understanding how the Amazon might change in the future due to global warming (Chapter 9).

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* Governments also invested in research in the applied sciences that contributed to the economic development of the region and, intentionally or otherwise, accelerated deforestation and environmental degradation. Among the most devastating consequences of this research and development was the evaluation and introduction of cultivated grasses of African origin combined with the genetic improvement of cattle breeds from South Asia. The Brazilian agricultural research service (EMBRAPA) transformed tropical agriculture by developing varieties of soybeans adapted to the humid tropics (Chapter 3). Research by plant pathologists and entomologists in Colombia and Ecuador overcame inherent limitations to plantation production systems to support the expansion of oil palm (Colombia) and cacao (Ecuador).

† Ecologists affiliated with the *Instituto Nacional de Pesquisas da Amazônia* (INPA) in collaboration with the Smithsonian Institution initiated *The Biological Dynamics of Forest Fragments Project* (BDFFP), a long-term experiment begun in 1979 to document how deforestation and fragmentation affect the composition, structure, and function of a forest ecosystem:

‡ *Red Amazónica de Inventarios Forestales* (RAINFOR) has published more than 200 peer-reviewed papers authored by 200 contributing authors; see: http://www.rainfor.org/en

Because ecologists count trees and measure their dimensions, they have revealed the dimensions of the Amazon's massive carbon reserves; more importantly, because they repeat their measurements periodically, they have discovered that the Amazon ecosystem has functioned as a net carbon sink over the last several decades. Surprisingly, they discovered that the photosynthetic capacity of intact primary forest was so great that wilderness landscapes have been sequestering more carbon on an annual basis than was being lost via deforestation and forest degradation on the forest frontier. Unfortunately, these same studies identified a trend of increasing tree mortality and a shift in species composition that may cause intact primary forest to become a net source of carbon emissions over the next decade. The shift in ecosystem function is due, in part, to alterations in the physiological processes in leaves stressed by periodic drought and high temperatures but also to a shift in the composition of tree species caused by increased tree mortality (Chapter 9).

Investments in forest ecology were matched by parallel efforts to observe and evaluate forest landscapes using remote sensing technology. Brazil led the way in the early 1980s with a commitment to annually quantify deforestation using satellite images, a decision that would have an enormous impact on the public debate about the expansion of the agricultural frontier (Chapters 2 and 9), as well as the decisions made in international forums dealing with climate change (Chapter 10). The protocols and technology developed by the Brazilian space agency have been adopted as a global standard and are now used by all the Pan Amazonian nations to monitor their own forest frontiers. Over time, innovation in remote sensing technology led to the deployment of satellite-borne sensors that could monitor deforestation in real time, as well as identify forest degradation from logging and wildfire (Figure 1.6). These studies complemented field research by forest ecologists, which allowed researchers to spatially map the distribution of forest biomass, as well as detect how seasonal and interannual variation in weather was impacting ecosystem function at the landscape, regional, and continental scales (Chapter 10).

Climate change and moisture recycling

Starting in the 1990s, ecosystem ecologists and atmospheric scientists in the Brazilian space agency embarked on a sophisticated collaboration with NASA and other international research institutions; their goal was to understand and model the interactions between the atmosphere, the ocean and the forest ecosystem. They collected data using instruments mounted on satellites, airborne platforms and canopy towers, a collaboration that discovered how cyclical anomalies in ocean temperatures, such as El Niño / La Niña, drive the decadal-scale droughts and floods that impact the Am-

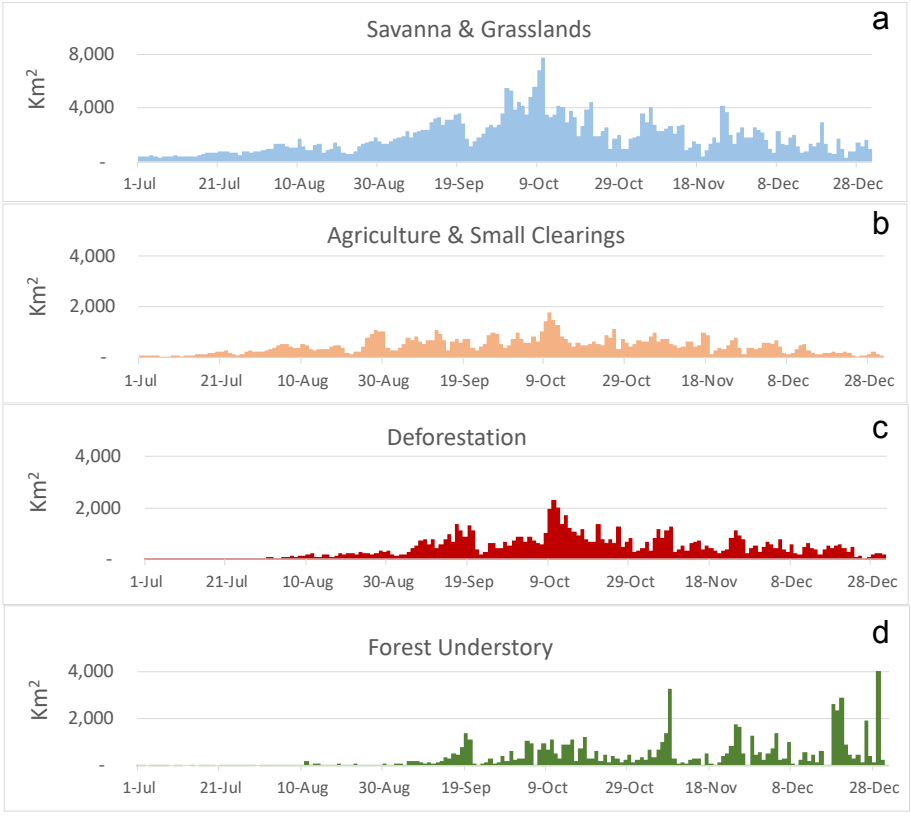

Figure 1.6: The 2020 fire season in the Amazon south of the Equator was typical: The burning season starts in July as landholders use fire to renovate pastureland (a) and clear fields on existing farms (b). The use of fire increases at the end of the dry season (September to October) when landholders burn recently deforested land to expand production (c). Managed fire escapes to create wildfire that impacts the understory of natural forest (d). The y-axis shows the area (km²) burned as measured by the MODIS instrument on NASA satellites.

Data source: Global Fire Emissions Database, Amazon Dashboard, https://globalfire-data.org/pages/amazon-dashboard/

azon. Their most important finding was to elucidate how tropical forests recycle water between the surface and the upper troposphere via a process known as 'deep convection'; sometimes referred to as a 'biotic pump'; this natural system maintains the high precipitation that defines the Amazon rainforest (Chapter 10).

The impacts of deforestation, forest fragmentation and forest degradation are all weakening water recycling, and this is enhancing the intensity and frequency of seasonal and interannual drought. The risk is particularly acute in the Southern Amazon, a climatic transition zone where subtle shifts in ecological succession can determine whether a landscape is dominated by forest or savanna species. When and if a forest community is established, feedback mechanisms will reinforce the biotic pump, which favours an equilibrium state that supports the maintenance of rainforest. A rapid transition to a non-forest equilibrium can occur if a key environmental factor, such as drought, wildfire or logging, passes a threshold that alters the microclimate that favours forest species. When that occurs, rain forest trees suffer high rates of mortality and are replaced by species adapted to open savanna-like conditions (Chapter 10).

Climate models show that drought in the Amazon will become both more frequent and intense, while higher temperatures increase stress on tropical trees. There is increasing concern that the Southern Amazon could suffer from two or more consecutive years of drought, which could trigger a large-scale forest dieback of cataclysmic proportions. Known as the 'tipping point hypothesis', it is a clarion call of the dangers from uncontrolled deforestation, illegal logging and the indiscriminate use of fire by small farmers and ranchers. The impact of a collapsing forest ecosystem would extend well beyond the loss of biodiversity in the remnant forests of the Southern Amazon because it would signal a dramatic reduction in rainfall across the region – and beyond.

The most economically significant discovery of recent years grew out of a collaboration between meteorological agencies to integrate the subregional manifestations of the annual wet and dry seasons into a common continental-scale climate system. Christened the South American Monsoon (SAM), it mediates the flow of water from the Atlantic Ocean westward across the Amazon, south along the base of the Andes and, eventually, southeast into the subtropical landscapes of Bolivia, Paraguay, Central Brazil and Northern Argentina (Figure 1.7). The combination of the water recycling driven by deep convection within the Amazon and the distribution of water across the continent by the SAM directly links the productivity of one of the planet's most important bread baskets – and the economic health of four nations – with the conservation of the Amazon rain forest (Chapter 9).

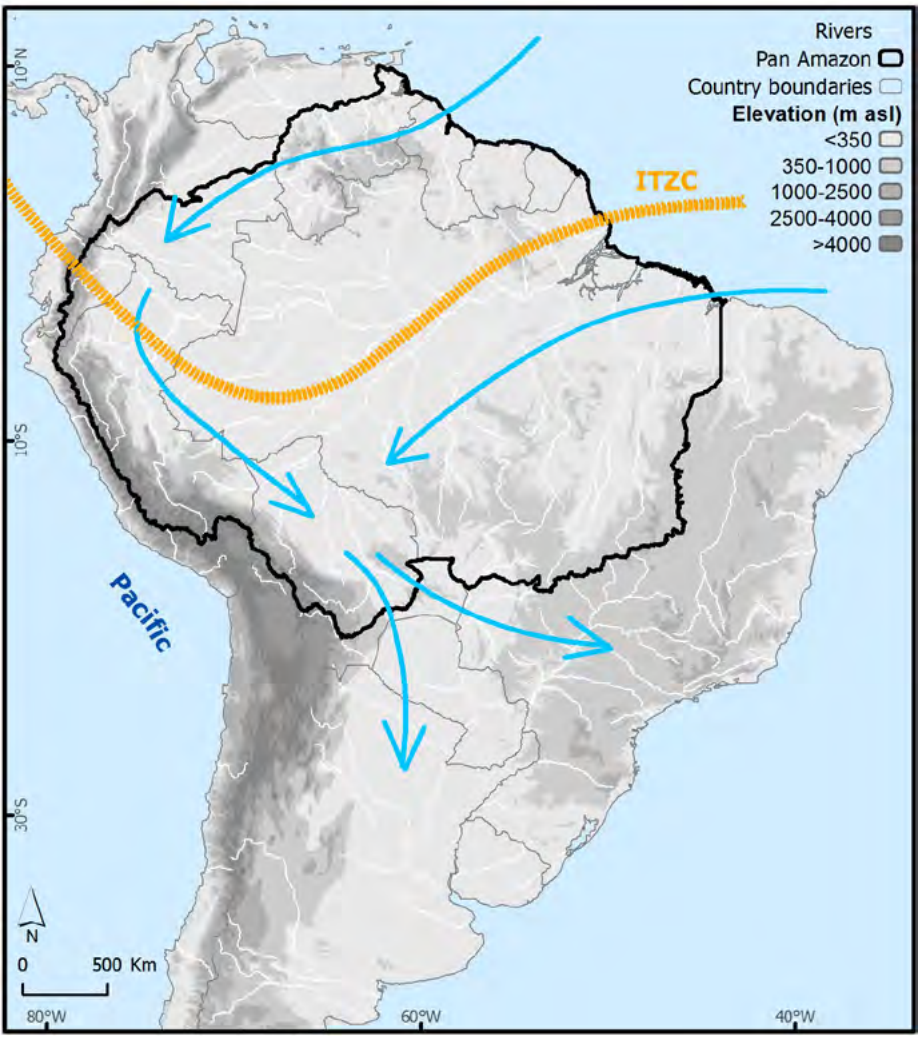

Figure 1.7: The South American Monsoon is established and controlled by the rotation of the Earth, the seasonal shift of the Inter Tropical Convergence Zone (ITCZ), the height of the Andes, and atmospheric pressure gradients driven by temperature differences across the South American land mass.

Data source: Marwan, N. and J. Kurths. 2015. 'Complex network based techniques to identify extreme events and (sudden) transitions in spatio-temporal systems'. *Chaos: An Interdisciplinary Journal of Nonlinear Science* **25** (9): 097609.

NASA (Public Domain)

Wildfires typically start when landholders burn pasture to renew forage or clear forest to establish new fields; managed fire often spreads into adjacent natural forest and, during drought years, can damage millions of hectares of primary forest habitat. This photograph of wildfires along the Río Xingu was taken by astronauts from the International Space Station in 2011.

NASA Earth Observatory, https://earthobservatory.nasa.gov/images/71256/fires-along-the-rio-xingu-brazil

Environmental Policy and Action on the Ground

From the outset, academics realised that the development programmes being deployed across the Amazon in the 1960s and 1970s would bring irreversible harm. Attempts to promote conservation were a natural outgrowth of their efforts to document the region's biodiversity and ecological complexity. They were not the first defenders of the Amazon, however; that distinction belongs to indigenous people who had been fighting to protect their way of life for centuries. These two groups, sometimes working together and sometimes independently, motivated citizens across the world to organise civil society groups, now known as 'non-governmental organisations' (NGOs), to advocate for biodiversity conservation, the protection of indigenous rights and eventually the transformation of the region's economy. Governments and the private sector have responded by implementing policies and adopting business practices that seek to staunch the deterioration of the environment.

It remains to be seen, however, whether these actions will be sufficient to change human behaviour on frontier landscapes or slow global warming within the timeframe needed to save the Amazon. These policies are now being called into question by newly elected governments in Brazil and Bolivia that have embraced conventional development models, by chaos in Venezuela, and equivocation in Ecuador, Peru, Guyana and Suriname.

Environmental governance

The Pan Amazon nations have constitutions that were reformed or rewritten in the last decades of the twentieth century. Previous versions either ignored nature or incorporated a simple clause assigning the state the 'duty' to protect [or improve] the environment. Brazil's constitution of 1988 was radically different: ten separate articles address nature conservation or environmental management by declaring that access to a healthy environment is a basic human right. The reformed national charters of Colombia (1991), Peru (1993), Bolivia (1994, 2009), Venezuela (1999) and Ecuador (2008) all include mandates to enact environmental legislation and create environmental ministries.* Ecuador's is the most emphatic, stating that Mother Nature (*Pachamama*) has rights that must be honoured by human society (Chapter 7).

Environmental ministries are responsible for developing environmental policy and administering agencies that regulate the public and private use of natural resources. Most share management responsibilities, however, with other agencies that reflect competing domestic agendas. For example, the national forest service is part of the Ministry of Agriculture in Brazil and Peru, while the regulation of water resources is shared with agriculture (Peru) or energy agencies (Brazil) or enshrined as a separate agency (Ecuador). Environmental ministries have well-defined responsibilities to oversee the management of the long-term environmental (brown) liabilities linked to the extractive sector (Chapter 5) and to review the potential harm from industrial development and infrastructure investments.

The stated goal of modern environmental management is to 'avoid, mitigate or compensate' the negative effects of modern development. The Environmental Impact Analysis (EIA) framework was introduced into Latin America in the 1990s, and EIAs are now routinely conducted as part of the due diligence and feasibility planning processes for major industrial or infrastructure investments. Like their counterparts in the advanced economies, these technical documents reflect the conflicting societal pressures between promoters of economic growth and advocates for nature conservation. Their methodologies are far from perfect, but their utilisation has

* The current constitutions of Guyana (1980) and Suriname (1987), adopted at their independence, have only a single clause dealing with the environment.

vastly diminished harm when compared to the *status quo ante.* The IIRSA initiative has sought to harmonise the EIA processes across the continent, which has improved the technical capacity of environmental ministries and facilitated private sector investment in much needed public infrastructure (Chapter 2).

Many environmental advocates view them as a greenwash, however, and there is ample objective evidence that the EIA service industry is biased toward the approval and completion of individual projects (Chapter 7). There are few examples of projects that have been canceled due to the discoveries identified in an EIA; instead, developers use the evaluation process to identify and modify specific aspects while ensuring projects move forward to completion.*

The dam and power plant at Jirau on the Río Madeira in Rondônia was built between 2008 and 2016 as part of the Programa de Aceleração do Crescimento – PAC (Growth Acceleration Program) over the objections of aquatic ecologists who advised it would alter natural flood cycles, impede the flow of sediments to downstream habitats and obstruct the migration of commercial catfish species essential to the livelihoods of thousands of river communities.

* The rare example of a cancelled project is the proposed dam at São Luis de Tapajós, which was canceled in 2017; in contrast, serial observations by both official and independent technical panels criticising the proposed dams on the Xingu River led to a reconfiguration of their components and the eventual construction of the Belo Monte facility between 2000 and 2019 (Ch. 2 and 7).

The limitations of the EIA system led to the development of a complementary approach known as a Strategic Environmental Analysis (SEA) designed to identify alternative development options far out into the future. The SEA is viewed as a way to avoid environmental degradation because it is predicated on the participation of civil society and local communities that would foresee and veto non-sustainable development pathways. There have been three high-profile attempts to conduct an SEA along highway corridors sponsored by the IIRSA initiative.* In each case, they contributed to the creation of one or more protected areas, but none substantially changed the economic and social forces driving deforestation in the landscapes impacted by those highways (Chapter 7).

Another strategic planning methodology embraced by governments is land-use planning that combines information on soil, water and biodiversity with social and economic data to make zoning recommendations for political jurisdictions. This approach was conceived in the 1970s to identify lands appropriate for agriculture but evolved into a more holistic system in the 1990s as governments reacted to the deforestation crisis. Referred to as *Zonificación Ecológica Econômica* (ZEE), these studies typically recognise the *status quo* of existing settlements and highways while discouraging development on fragile lands or areas of exceptional ecological or cultural value (Chapter 5). The legal standing of these technical documents varies among countries, but most are aspirational rather than mandatory. Settlers, local elites and entrepreneurs use them to identify land with arable soils but all too often ignore recommendations based on environmental criteria. ZEEs have been used in Brazil and Bolivia to identify areas that were incorporated into protected area systems and to bolster the claims of indigenous or traditional communities (see Chapter 11).

One of the most conflictive governance issues in the Pan Amazon revolves around forest management. The constitutions of all eight nations establish sovereign (state) control over forest resources. This obviously covers all aspects of the management of public forests, but it also includes the forest resources located within private properties. To observers from cultures that recognise the priority of property rights, this would seem an aberration; nonetheless, it is a fundamental aspect of these nations' legal systems.† Moreover, virtually all of the landholdings within the Amazon were issued (albeit provisional) deeds that recognise this legal principle;

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* *Corridor Bioceanico (Santa Cruz–Puerto Saurez); Corridor Interoceanico del Sur and the Madre de Dios–Acre– Pando (MAP); Plano de Desenvolvimento Regional Sustentável la paraa Área de Influência da Rodovia BR0163 Cuiabá–Santarem.*

† This aspect of jurisprudence is linked to their colonial history when the land and its resources belonged to the crown, which granted concessions and use-rights to individuals and companies. It also underpins the legal basis for the state to claim dominion over all underground mineral resources (Ch. 5 and 7).

consequently, their property rights are clearly circumscribed by precedent and law. Regardless, human nature often supersedes legal tenets, and there is enormous resistance by property owners to comply with rules and regulations emanating from government agencies.

The conflict between private property and forest governance is most evident in the Brazilian government's attempts to enforce the Forest Code, a landmark regulatory framework first promulgated in 1936 and most recently revised in 2012. The 1965 version established that landholders in the Amazon could clear only twenty per cent of their land for agriculture or ranching and must retain eighty per cent in its natural state (Chapter 7). Landholders have the right to exploit forest resources, but they must comply with a variety of management criteria.* The Forest Code was blatantly ignored throughout most of the 1970s, 1980s and 1990s, when landholders cleared land in excess of the legal limit, as well as along river corridors that merit special protection.

In 2005, the government of Brazil launched the *Plano de Ação para Prevenção e Controle do Desmatamento na Amazônia Legal* (Action Plan for Prevention and Control of Deforestation in the Legal Amazon; PPCDAm), an ambitious campaign to bring the combined resources of the Brazilian state, using 'carrot and stick' policies, to the reduction of deforestation. Directed from the president's office, it imposed coordination across ten ministries and a dozen autonomous agencies. Satellites captured accurate and precise data in real time, which law enforcement teams – led by the public prosecutor's office, with support from police, tax authorities, and the environmental protection agency – used to identify illegal activities (Chapter 7). Simultaneously, the federal government coordinated its actions with state governments to implement a land registration and reporting system that provides landholders with a flexible pathway to remediate past infractions of the Forest Code. Consumer boycotts reinforced these actions, forcing multinational corporations to implement supply chain certification systems eliminating production sourced from properties engaged in illegal activities. Coercive measures were combined with incentives such as technical assistance and financial credit from both public and private entities, measures that increased yields and revenues from previously deforested landscapes via the 'intensification' of production instead of the 'extensification' of land use (Chapter 4).

These PPCDAm and related actions led to an eighty per cent drop in deforestation in the Brazilian Amazon between 2005 and 2012, an astonishing turn of events that led optimists to proclaim that deforestation

* In the case of timber, landholders must conduct an inventory and then adopt a cutting cycle that ensures the survival of viable populations of each species; since this is not known for most species, a 30-year harvest cycle is recommended as a default.

had been decoupled from agricultural production. The 'carrot and stick' incentive system was designed primarily for agribusiness, particularly farmers producing soy and beef for export markets. The most effective coercive policies excluded smallholders and, consequently, did little to change land-use practices on the most active forest frontiers. Ranchers realised that the government lacked the political will to collect environmental fines and developed workarounds to trade cattle from properties engaged in illegal deforestation. Deforestation increased from a low of 457,000 hectares in 2012 to 976,000 hectares in 2019, a value far below the 2.7 million hectares of deforestation registered in 2004, but analysts forecast the trend will continue in the regulatory environment following the elections of 2019.

The anti-deforestation campaigns in the Andean republics never contemplated an all-of-government effort to reduce deforestation, although, in Peru, a multi-agency task force has used a newly implemented monitoring system to intervene in a few highly publicised incidents.[13] Perhaps more importantly, there are no corresponding global commodity supply chains that might motivate companies, governments, and landholders to change their business practices (Chapter 3).*

The largest land set-aside in history

The commitment to environmental governance in the 1990s was preceded by a civil society movement to create national parks and wildlife refuges. In the first half of the twentieth century, the Amazonian nations created a dozen or so national parks, thanks largely to the efforts of farsighted and passionate individuals with political influence. In most cases, these efforts were both isolated and unsustainable because governments failed to allocate financial resources for their management and protection. Serious efforts to create national protected area systems began in the 1970s as part of the global effort to protect nature and wildlife. International NGOs and the United Nations played prominent roles because they had public relation skills and the legitimacy to garner the attention of national governments. More importantly, domestic opinion supported their creation (Chapter 10).

The first cohort of protected areas was characterised by spectacular examples of biodiversity and scenic beauty: the *tepuis* of Venezuela, the isolated table-mountains of Colombia and the snow-covered peaks of the High Andes. Academics used their knowledge, which was still rudimentary, to advocate for selected lowland landscapes that were exceptionally diverse or ecologically unique (Chapter 9). Brazil established reserves in different parts of the Amazon, operating on the assumption that they would be dif-

* Coffee and cacao have decentralised supply chains that lack critical points sensitive to boycotts, while the palm oil producers in Peru and Ecuador largely produce for domestic markets. Ch. 3.

ferent and, therefore, complementary. Ecuador was the first nation to create a coherent national system in the early 1980s when it designated areas in all of that country's major biogeographical formations. Brazil, Colombia and Venezuela created the core components of their national system between 1988 and 1991, and Bolivia followed suit in the mid-1990s. The growth in the protected area network proceeded at phenomenal speed, catalysed by donations from the advanced economies and multilateral development agencies. Designations increased by ~10% annually between 1965 and 1995 and by ~5% annually until 2015; as of 2019, approximately 28% of the surface area of the Pan Amazon had been set aside into some sort of state-sponsored protected area (Figure 1.8).

Many of these new protected landscapes were home to communities whose livelihoods depended on the natural resources within reserves, which created scenarios for potential conflict and failure. The Man & Biosphere Program of the United Nations provided a philosophical framework for managing the relations between resident populations and park managers while sponsoring pilot projects in high-profile protected areas. These experiences informed a rapidly emerging consensus that protected area systems must reflect the diversity of management challenges characteristic of developing countries. Each country responded accordingly and created a plethora of categories that reflect its respective social realities and the political compromises required to set aside large areas within their Amazonian jurisdictions (Chapter 12).

The IUCN* provides a classification system that offers a logical framework for comparing the multiple different categories in six groupings, which include those afforded 'strict protection,' such as national parks and monuments, and others to be managed for 'sustainable use,' such as forest reserves and buffer zones around national parks (Figure 1.8). The concept of sustainable use reserves was pioneered by Chico Mendez, a human rights activist who led the rubber tapper workers union in Rondônia and Acre in the 1970s and 1980s. His murder by land grabbers in 1988 motivated the Brazilian government to create a new category of protected area, *Reserva Extrativista* (RESEX), which recognised the rights of families whose livelihoods were dependent on forest and wildlife resources (Chapter 12).

The proportion of Amazonian territories set aside as nature reserves varies between countries, ranging from a high of 75 per cent in Venezuela to a low of five per cent in Guyana. The differences are smaller than they seem, however, depending upon what is considered a protected area. For example, forest reserves that allow logging have been incorporated into protected area systems in Brazil and Venezuela but not in Bolivia, Colombia, and Peru. The two countries with the lowest designated protected area,

* International Union for the Conservation of Nature (IUCN).

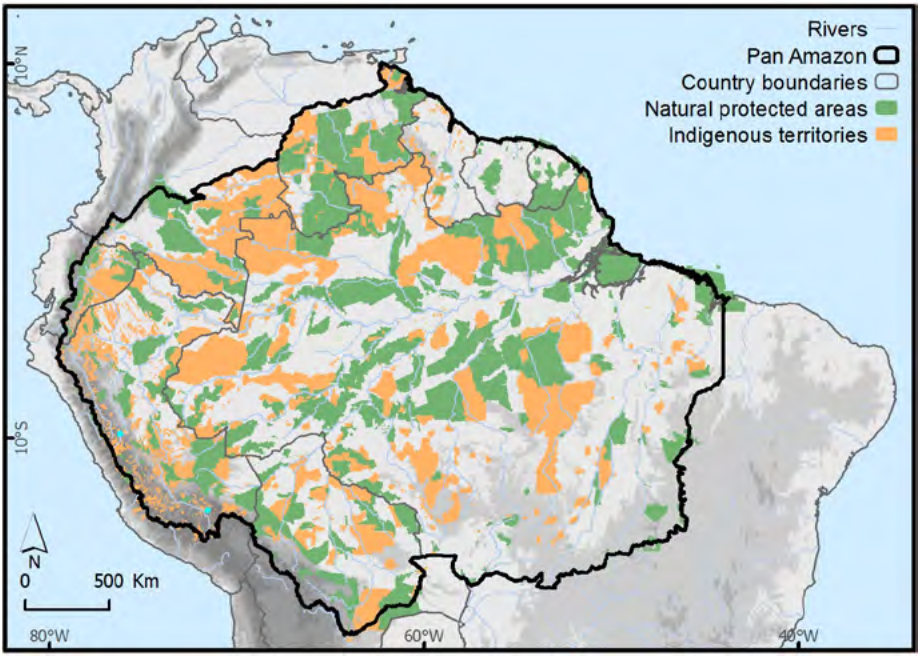

Figure 1.8: The protected area network can be roughly stratified into strict protection areas and sustainable-use areas; indigenous territories are broadly organised into community-based landholdings, which tend to be smaller in area and territorial based reserves that include multiple communities.

Data source: *Rede Amazônica de Informação Socioambiental Georreferenciada* (RAISG), https://www.amazoniasocioambiental.org/

Guyana (5%) and Suriname (15%) retain extensive areas within the forest estate (~50%) that are being held in reserve for future timber exploitation (Chapter 8). Some indigenous territories have been incorporated into protected area systems, while others have not (see below). Brazil and Peru also have large areas that have not been allocated to any management category or tenure regime.

The consolidation of the protected area system is an ongoing process. All but a few parks and reserves are understaffed, and all lack budgets adequate to the task of managing tens of millions of hectares of forest landscape. Some protected areas were created with pre-existing social conflicts

linked to illegal mining,[*] the cultivation of coca[†] or cattle ranching.[‡] The goal of sustainable management is largely aspirational and will depend on the willingness of inhabitants to pursue livelihoods compatible with management guidelines, which in turn will depend on their ability to obtain a quality of life commensurate with their personal aspirations. Recent trends in several RESEX reserves show that families have opted to clear land and establish small agriculture operations because the economic benefits from forest-based production models do not meet their needs for cash income.[§] In some jurisdictions, opposition to protected areas by influential constituencies threatens to overturn or downgrade their status.[¶]

In spite of these challenges, or perhaps because of them, civil society groups continue their campaigns to expand protected area networks. The designation of national protected areas has slowed, but efforts to create regional and local parks, reserves, and recreational areas have increased, especially in the Andean republics where administrative authority has only recently been devolved to subnational jurisdictions (Chapter 7). Although local business elites support conventional development models, creating protected areas under local control is popular with broad sectors of the electorate.

An Indigenous revival

The explosive growth of protected area networks was accompanied by the simultaneous recognition of the territorial rights of indigenous people, an ongoing process that has yet to conclude. There are approximately 2.5 million indigenous people living in the Pan Amazon; about two-thirds live

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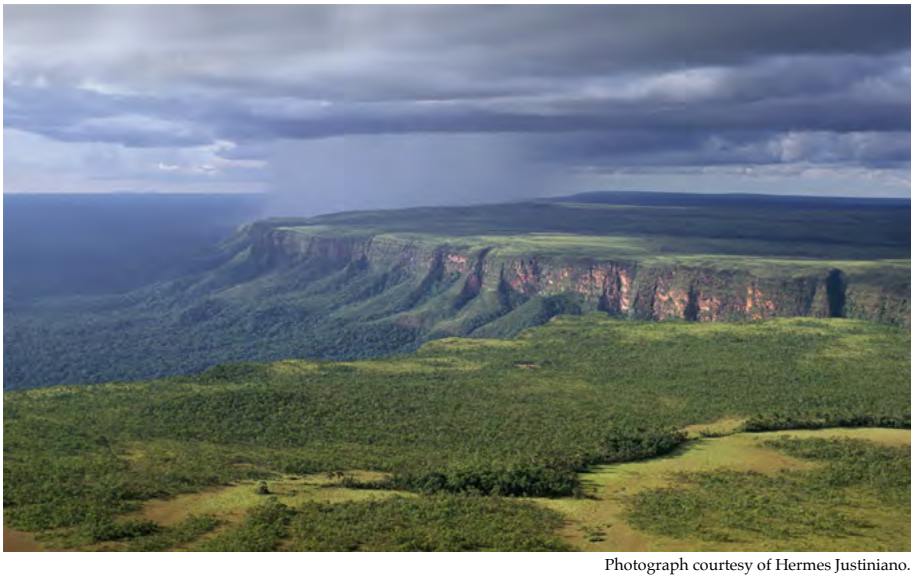
* Brazil: Floresta Nacional (FLONA) Jamanxim, Crepori, Itaituba-I; Area Protección Ambiental (APA) Tapajós; Parque Nacional (PARNA) Jamanxim, Río Novo. Venezuela: Reserva Forestal (RF) Imataca, La Paraguay, Sipapo; Parque Nacional (PN) Canaima, Caura, Parima-Tapirapeco; Reserva de la Biósfera Alto Orinoco-Casiquiare; Peru: Reserva Nacional Tambopata; Bolivia; Parque Nacional Madidi; French Guiana: Parc Amazonien de Guyane

† Bolivia: Parque Nacional (PN) Isiboro-Securé, Carrasco; Area de Manejo Integral (AMNI) Amboró; Colombia: Distrito de Manejo Integrado (DMI) Macarena Norte.

‡ Brazil: FLONA Jamanxim, Reserva Biológica (RESEB) Nascentes da Serra do Cachimbo, APA Triunfo do Xingú.

§ Almost all resident families in oldest extractive reserve in Brazil, RESEX Chico Mendes, have cleared small forest patches ranging in size from a few to more than a hundred hectares and are increasingly dedicated to cattle ranching, while RESEX reserves in Rondônia resemble colonisation landscapes with linear deforestation similar to colonisation zones. Ch. 8.

¶ The state legislature of Rondônia revoked the status of ten protected areas in 2018 as a backlash when a governor created a protected area on the last day of his term by executive decree rather than legislative action. Ch. 10.



Photograph courtesy of Hermes Justiniano.

The nations of the Pan Amazonian have created the world's largest network of nature reserves to protect the biodiversity and scenic beauty of places such as the Anavilhanas archipelago on the Río Negro (Amazonas, Brazil) and the Serranía de Caparú in Noel Kempff National Park (Santa Cruz, Bolivia).

within their territories, which total between 170 and 220 hundred million hectares (Figure 1.8 and Table 1.3). They have occupied and defended these territories for centuries; historically, they used armed resistance, but they now rely on civil disobedience and political activism. Being granted legal title or explicit use-rights to their homeland, however, does not signify an end to conflict. Indigenous communities must physically protect their land and its resources from timber thieves, gold miners and land grabbers, as well as wage regulatory battles to stop highway construction, petroleum exploration or the development of hydropower infrastructure (Chapter 11).

Indigenous people are the Amazon's fiercest and most effective conservation advocates because the struggle for their territories is existential: if they lose their land, they will lose their identity and cease to exist as a people. They know this because they are the survivors of a holocaust.

The Native Americans of the Pan Amazon have survived wave after wave of genocidal events that started with the colonisation of the Western Hemisphere by the European powers in the fifteenth and sixteenth centuries.[14] Slavery, war and epidemic disease reduced their populations by an estimated ninety per cent by the mid decades of the nineteenth century. The prosperous communities that once populated the main stem of the Amazon River were not entirely annihilated; their languages disappeared, but survivors were absorbed, along with their knowledge, into the mestizo culture that now occupies the banks of the river.*

The ethnic groups that survived with their culture and languages intact did so by retreating to remote territories on upstream tributaries that limited their contact with the agents of Western civilisation. Some tribes interacted with missionaries and frontier merchants, participating in the Amazonian economy by trading a diversity of forest products, including gums, resins, fibre, fruits, nuts, wildlife and fish. They were unprepared, however, for the avalanche of invaders who arrived with the onset of the first rubber boom in the last half of the nineteenth century (Chapter 6). The number of dead has never been compiled, but tens of thousands perished from another round of disease and slavery. The surviving tribes moved deeper into the wilderness.

The period between the end of the first rubber boom and the nationalist policies of the 1970s was a time of relative calm. Outsiders continued to seek out indigenous communities, but they now came with benevolent intentions. Catholic and Protestant missionaries renewed their efforts to bring salvation to so-called heathen populations; their most consequential action was to educate young men, and sometimes women, as part of a deliberate strategy to assimilate ethnic groups into Western society. The

* Along the mainstem of the Amazon River, they interbred and merged with immigrants who gave rise to the *Cabloco, Quilambolo and Ribereño* traditional communities. See Ch. 6.

Table 1.3: The ethnic populations of the Pan Amazon and their territorial claims in 2017[28]

	Groups Extant/ Extinct	Indigenous Population	Territorial Units	Formalised + Legalised (hectares)	Claimed + Pending (hectares)
Brazil	174/9	708,474	428	106,906,612	8,789,287
Bolivia	33/4	244,386	94	11,711,762	7,164,531
Colombia	49/4	253,711	185	26,217,159	
Ecuador	8/1	349,935	+/-200	4,095,851	3,667.168
Peru	73/4	615,555	1,500	14,568,446	5,360,988
Guyana	8/0	82,561	128	3,167,297	~3,000.000
Suriname	10/1	25,792	50		3,424,063
Venezuela	29/4	271,996	10	1,186,539	30,580,859
F. Guiana	7/0	25,333	22	715,223	
Total	**340/39**	**2,577,743**	**2,461**	**168,568,889**	**56,138,396**

Brazilian government created the *Serviço de Proteção ao Índio* (SPI), which sought to 'pacify' indigenous groups and integrate them as distinct cultures into Brazilian society.* Expeditions and trading stations were manned by *sertanistas*, many of whom admired indigenous cultures and sought to protect them from modern society.† A third group of individuals combined both missionary and anthropological approaches: evangelical Christians organised a highly effective effort to preserve indigenous languages, recognising their essential role in cultural survival. Ironically, they used that knowledge to translate the bible into native languages and, in the process, attack the spiritual elements at the core of indigenous culture (Chapter 11).

All three of these interlopers acted as mentors to indigenous people as their societies adapted to a changing world in the first half of the twentieth century. Each contributed to the survival of the indigenous people with whom they interacted; unfortunately, many exchanges triggered another round of epidemic disease. Indigenous people were not passive recipients of their ministrations, however; they absorbed some lessons while ignoring others. More importantly, they retained their own leadership traditions, which they would harness to navigate the next existential threat to their

* The SPI was established under the leadership of Cândido Rondon, an army officer of indigenous descent, famous for his Amazonian expeditions and his philosophy of how to contact and interact with indigenous tribes.

† *Sertanistas* were known for their backwoods skills and ability to live among indigenous communities; some were autodidact anthropologists and contributed information to academic studies that documented ethnic cultures; others were scoundrels and took advantage of their positions within the SPI to engage in corrupt acts.

Photographs courtesy of Eric Stoner.

Megaron Txucarramae is a leader of the Kayapó, an indigenous nation (~8,000 individuals) that has pioneered self-governance within their territories in Pará, seen here addressing a seminar where forest rangers received training to combat wildfire, illegal logging and other types of encroachment on their territory in Mato Grosso.

way of life. The already considerable pace of change was hyper-charged by the tumult of the 1970s and 1980s as immigrants streamed into their territories with government assistance and the explicit intention of stealing their land. Fleeing further into the forest wilderness was no longer an option. They had to organise and fight, or they would perish. Typically, a group of individuals would form an association united by ethnicity and language; not infrequently, they were led by a charismatic individual who had been indoctrinated by a Western mentor. In a remarkably short period of time, individual ethnic associations united to form national federations to represent their interests to government. This happened independently in Brazil, Bolivia, Colombia, Ecuador and Peru; simultaneously, they organised internationally to create an Amazonian coalition of indigenous organisations.* By design or good fortune, their movement coalesced at a time when these nations were undergoing democratic renewal and constitutional reform. By the end of the 1980s, the Andean republics and Brazil explicitly recognised the rights of indigenous people to their ancestral territories and some form of autonomous government.

The first indigenous territory was actually conceived as a national park: *Parque Nacional do Xingu* was created in 1961 and, at the time, was the largest protected area in Brazil. Its proponents, a trio of brothers who were famous *sertanistas*,† based their ambitious proposal on their observations that indigenous cultures are inextricably linked to their livelihoods, which are entirely dependent on access to forest and aquatic resources (Chapter 11). To protect indigenous culture, it is necessary to conserve the landscape that supports the livelihood of the entire tribe. The park was declassified as a protected area in 1991 and recognised solely as an indigenous territory: *Parque Indígena do Xingu* (PIX).

Prior to its formation, the amount of land deeded to a village or community was calculated based on the area required to support a family using slash-and-burn technology, rather than the territory needed to pursue a forest livelihood. Another key decision was to include multiple communities in a single reserve, which also increased the size of the protected area. This provision obligated different tribes, many of whom were historically hostile, to collaborate in the administration of their shared territory (Chapter 10). The PIX set a precedent in Brazil, but very few indigenous territories were created during the military government between 1964 and 1985. The recognition of indigenous territories began in earnest with the constitutional reform of 1988.

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* *COICA: Coordinadora de las Organizaciones Indígenas de la Cuenca Amazónica.*

† The Villas-Bôas brothers lived among the indigenous people on the upper Xingu River in the state of Mato Grosso; their proposal, made originally in 1952, had the support of Cândido Rondon and other key military officers. See Ch. 10.

The recognition of the territorial rights of indigenous communities in the Andean republics occurred first in Peru, when a military government initiated an agrarian reform policy in the early 1970s. The Peruvians adopted a community-based model that deeded land to individual villages, rather than a territory-based model that pooled the lands of multiple communities. This policy has created a fragmented land tenure map, which has facilitated the development of energy infrastructure while impeding indigenous organisations' efforts to limit the expansion of the oil industry in northeast Peru (Chapters 5 and 6).

In Bolivia, the government of Evo Morales changed the nature of its territorial system, which was originally established using ethnic affinities, to allow new settlements by migrants from indigenous highland communities. Guyana adopted a community-based approach that limited the forest area ceded to indigenous tribes while maximising the forest estate under government control. Suriname has yet to act to create any indigenous territories, in spite of a decision by the Interamerican Court of Human Rights in favour of the two largest groups,* who petitioned the court to seek restitution for environmental impacts linked to the bauxite industry (Chapter 5). Venezuela has recognised the rights of indigenous people in some protected areas but has yet to act on the territorial claims of its very sizable indigenous population (Table 1.3).

Although Peru relies heavily on the community-based model for allocating land to ethnic groups engaged with modern society, it has deployed the territory-based model to protect indigenous groups who are in voluntary isolation. Previously referred to as 'uncontacted' indigenous groups, these small bands are known to exist in Brazil, Bolivia, Colombia, Ecuador and Venezuela. Estimates vary, but there are probably less than 10,000 individuals living in about sixty bands in the most remote corners of the region (Figure 1.9).[15] These are among the most vulnerable groups within the Amazon because they are susceptible to common diseases and have not acquired the social skills to protect themselves from the vagaries of life that are an integral part of modern society.

The people living in voluntary isolation are not the only vulnerable cultures in the Amazon. Approximately ten per cent of the ethnic groups in the Amazon have become extinct since anthropologists compiled a (more or less complete) list in the first half of the twentieth century.[16] Cultural extinction is a forgone conclusion for forty groups with populations of less than 100 individuals, and the future is only marginally better for another 82 tribes with fewer than 500 souls, particularly if they have not retained the use of their language.[17] Overall, however, indigenous populations have approximately quadrupled since the 1970s, a positive sign that their health

* *Lokono (Carib)* and *Kalina (Arawak)*.

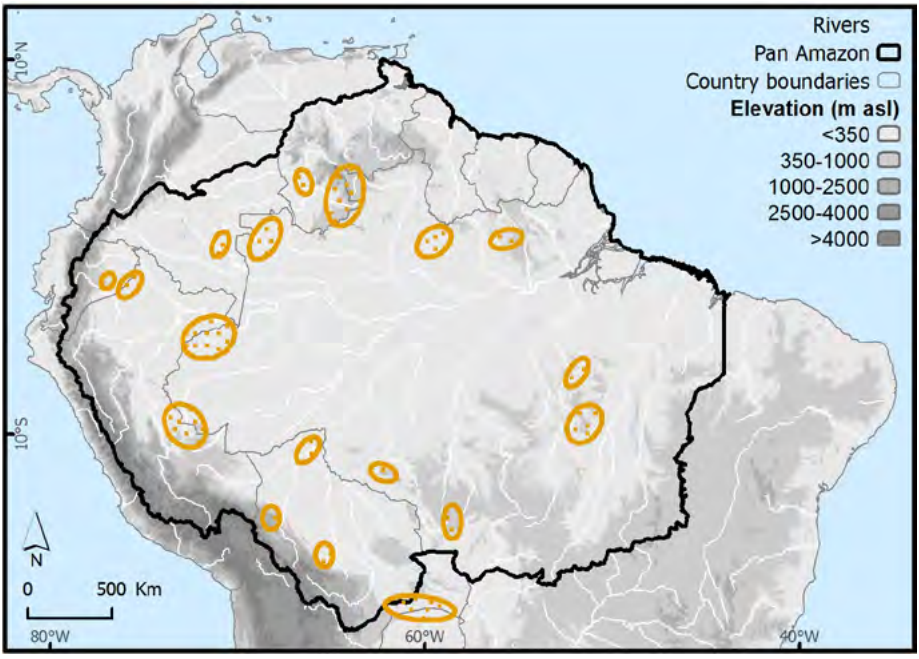

Figure 1.9: Most indigenous groups living in voluntary isolation live in remote areas on the border between Amazonian nations.

Map courtesy of International Work Group for Indigenous Affairs. Shelton et al. 2013.

and welfare has improved in parallel with efforts to secure their lands. Most of that growth has occurred within the fifty largest ethnic groups, who have been most successful in protecting their rights and prerogatives (see Chapter 11).

These numbers underestimate the actual indigenous population because of migration to urban centres by youth. Urban populations are both an opportunity and risk for indigenous people. If they retain their indigenous identity, urban populations can act as a conduit for information, technology, education and financial resources. Unfortunately, history has shown that it is more likely they will lose their language and adopt the cultural identity of the far more numerous mestizo population.

The revitalisation of indigenous communities has paid monumental dividends for Amazonian society (Text Box 1.3). Their commitment to biodiversity conservation ensures their territories will be managed as sustainable use reserves, and most adhere to management criteria similar to the most restrictive type of protected area. Their commitment is hard-wired into their culture, reinforced by recent history and the bitter struggle to defend their lands (Chapter 10). They are quite literally conservation warriors.

Text Box 1.3: Conservation Warriors

Kayapó: Opposed the development of multiple hydropower facilities on the Xingu river, confronting land grabbers and timber thieves. They have organised a self-defence system that serves as a model for other indigenous groups.

Mundurukú: Have protected their lands from gold miners and maintained a strategic presence at the falls at São Luis do Tapajós, where they mounted a successful campaign in opposition to a dam that would have opened the Tapajós as a waterway for grain exports.

Yanomami: Mobilised public opinion, which forced the state to use the army to combat illegal gold mining, while alerting the world to the plight of uncontacted communities in the face of epidemic diseases.

Amaerikaeri: Displaced from their lands by the illegal gold miners in the Madre de Dios, but continue to fight to protect their lands in the foothills.

Asheninka: Fought a long and hard battle with the Sendero Luminoso terrorist organisation and their allies among the coca growers in the foothills of the central Andes.

Moxeños: Defend their lands against a government intent on building a highway through the middle of their territories that would expand the settlement footprint for coca cultivation.

Waorani: Led the battle to stop the expansion of oil production in Yasuní National Park by taking their case to the Interamerican Court of Human Rights

Ashuar: Oppose new oil drilling by the state, while suing the government in court to hold them accountable for the damage from oil spills caused by negligence in the management of a forty-year old pipeline.

Photograph courtesy of Eric Stoner.

Warriors celebrating the Kuarup, an intertribal ceremony honoring the dead practiced by the inhabitants of Parque Indígena do Xingu (PIX), Mato Grosso. The PIX was established in 1961 as the Amazon's first multi-ethnic indigenous territory; today it is home to more than 8,000 Native Americans, belonging to 16 ethnic groups pertaining to five distinct linguistic lineages.

Source: *Povos Indigenas no Brasil, Instituto Sociamiental* (https://pib.socioambiental.org/).

Monetising the Value of Ecosystem Services – or Not

Environmental economics views the environment as a form of natural capital: land, water and biodiversity are viewed as assets that mediate the flow of goods and services from ecosystems toward human society. One of that discipline's most important innovations was the concept of payment for ecosystem services (PES), based on the observation that, under certain circumstances, societies are willing to pay for the provision of goods and services that originate from nature. The Pan Amazon is the most biologically diverse tropical forest on Earth, its forests and soils contain the largest stock of terrestrial carbon and it is home to the world's largest freshwater resource. Nonetheless, it has been difficult to discover and implement PES schemes capable of monetising the value of this enormous natural capital.

With regard to biodiversity, its value remains hypothetical until discovered; consequently, the market potential of the vast majority of Amazonian species is unknown. The foundation of the modern pharmaceutical industry is based on chemicals derived from plants, fungi and animals, but the discovery process is long, difficult and laden with risk. Similar obstacles impede investment by agribusiness: research to discover the economic potential of agrobiodiversity is largely carried out by public institutions. A PES scheme for biodiversity is not an option, because the potential beneficiaries of an undiscovered species have not been identified.

The value of water is easier to estimate because we consume it on a daily basis; nonetheless, developing PES schemes is difficult because Amazon has a surplus of water. It is implausible to ask consumers to pay for conservation in the name of water, except in a limited number of situations characterised by local scarcity. For example, urban water districts in the Andes often incorporate the cost of nature conservation in monthly water bills; similarly, rural communities dependent on irrigation in dry Andean valleys have developed PES schemes to compensate neighbors in cloud forest habitats that act as water towers. In all instances, the connection between provision and consumption is circumscribed to a local watershed. At larger scales, water is viewed as a free resource.

Two recent scientific discoveries provide an opportunity for a novel, continental-scale, PES scheme based on water: (1) Deep convection, which maintains rainfall over the Amazon, is threatened by deforestation and forest fragmentation; and (2) the SAM transports water from the Amazon to the agricultural landscapes of the subtropics (Chapter 10). The combined agricultural economy of the Paraná-Paraguay Basin was reported as approximately $US 200 billion in 2018; productivity losses due to drought stress are common and translate into billions of dollars of loss in revenue. Unfortunately, a PES scheme is unlikely because it would require the transfer

of money to Brazil from a less wealthy nation (Paraguay) and a geopolitical competitor renowned for poor governance (Argentina).

Fortunately, Brazil has the capacity and institutional infrastructure to implement a domestic rainfall-based PES programme. The federal government already supports Amazonian states via revenue transfers embedded within the annual budget process; public expenditures are the largest component of the economy in Acre, Amapá, Rondônia and Roraima (Annex 1.1). The system could be expanded into a *de facto* PES system by increasing funding for programmes known to support water recycling on frontier landscapes, including forest conservation, reforestation, agroforestry and low carbon agriculture (Chapter 8).

The potential value of forest carbon has motivated all the nations on the planet to create a global PES scheme based on carbon offsets.* In 2009, the signatories to the United Nations Framework Convention on Climate Change (UNFCCC) agreed to implement a system referred to as 'Reducing Emissions from Deforestation and Forest Degradation' (REDD+). At the time, it was assumed the advanced economies, and possibly China, would agree to mandatory reductions in greenhouse gas (GHG) emissions and the adoption of a cap-and-trade carbon market to generate demand for forest carbon offsets. Unfortunately, the United States failed to adopt a coherent climate change strategy, and the anticipated cap-and-trade compliance market has yet to materialise.

In the intervening period, the countries of the Pan Amazon have invested in a variety of REDD+ initiatives, motivated by the possibility that the US would eventually adopt supportive policies. They were encouraged by multilateral development agencies and civil society groups that provided financial resources to create the necessary institutional infrastructure and to test modalities for investing the revenues from an eventual REDD+ system. This preliminary system has been operating since its inception by generating carbon offsets that have been monetised within a voluntary carbon market or via *ad hoc* agreements negotiated by multilateral or binational development agencies (Chapter 12).

The Brazilian government integrated its REDD+ policies within its national climate change strategy and elected to monetise emission reductions via the Amazon Fund (*Fundo Amazônia*). According to the rules established by the REDD+ process, the decline in deforestation between 2005 and 2017 reduced CO_2 emissions from the Brazilian Amazon by ~1.5 gigatons.[18] The Brazilian government contends those reductions should be worth ~$US 22 billion based on a projected price of about ~$US 15 per ton of CO_2. Donations to the Amazon Fund have totaled $US 1.3 billion, which translates

* A carbon offset is a reduction in emissions of CO2 or other greenhouse gases (GHG) that is traded to compensate for emissions made elsewhere.

into a carbon offset price of $US 0.86 per ton of CO_2.[19] Brazil has pursued policies to reduce deforestation for multiple reasons, including to protect its export markets and respond to a domestic constituency concerned about the Amazon (Chapter 10), but when viewed as investment in REDD+, those policies have not been particularly lucrative.*

Brazil's commitment to the REDD+ system is currently under review by the newly elected government, which campaigned on a platform of promoting conventional development in the Brazilian Amazon. The two major contributors to the Amazon Fund, the governments of Norway and Germany, suspended their contributions in late 2019 to protest against the change in policies by the newly elected administration of Jair Bolsonaro. This conflict has revealed different interpretations of the REDD+ agreement: Brazil contends that it should be compensated for past performance, while the donor countries believe their ongoing contribution is based on future emission reductions, or at the very least, a commitment to maintain policies to combat illegal deforestation.[20]

The Andean countries, Guyana and Suriname all participate in REDD+ initiatives organised by the United Nations and The World Bank, as well as in several binational programmes sponsored by individual donor countries. Numerous REDD+ initiatives have been arranged and financed by civil society organisations that have yet to monetise their carbon offsets; presumably, they are holding certificates in anticipation of a future cap-and-trade market. As of 2020, there was no published estimate of their market value, although they report a total surface area of 44 million hectares.[21]

Perhaps the most interesting REDD+ initiative is the Governors' Climate and Forest Task Force, a coalition of subnational jurisdictions working to create a framework through which emissions reductions can be monetised independently of national policies.† The jurisdictional approach simplifies the challenges and mitigates many of the risks associated with monitoring deforestation, while providing a politically expedient framework for distributing revenues generated by emission reductions. In addition, advocates propose to add value to REDD+ by incorporating mechanisms for counting carbon removals that might occur due to changes in soil management or other opportunities created by low emission development strategies (LEDS).

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* Other REDD+ initiatives involving the Brazilian state include a project financed by the Green Climate Fund (GCF) to support the conservation and restoration of forest remnants on private properties ($96.4 million) and a programme implemented by the state environmental agency in Acre to promote forest conservation ($US 163 million).

† The initiative is led from California and Illinois in the USA, which seek to implement climate change policies in spite of the lack of action on the part of the federal government. Bridge financing for the GCF-TF is being provided by the governments of Norway, Germany and the United Kingdom.

Participating jurisdictions include all eight state governments in the Brazilian Amazon, Peru, Ecuador and Colombia (Chapter 12).

REDD+ has failed to provide the resources necessary to halt deforestation, much less transform the regional economy. This failure is ascribed to the inability of the advanced economies to put a significant price on carbon emissions; however, even if REDD+ revenues were increased, they might not be sufficient to overcome the multiple complex factors that drive deforestation. Even less likely is the prospect for money to be allocated for the reforestation of tens of millions of hectares of degraded pastures that climate modellers assert is needed to stabilise the precipitation regime of the South American continent.

The Challenge of the Future (and Lessons from the Recent Past)

The current development trajectory of the Pan Amazon is uncertain. The ongoing investment in protected areas and indigenous territories has created a solid foundation for conservation of the region's biodiversity. The dramatic reduction in deforestation in Brazil probably avoided an ecological catastrophe and identified key public policies with the potential for bending the arc of Amazonian development. Nonetheless, the momentum of fifty years of chaotic economic growth, disregard for the law and the economic power of vested interests continue to impede efforts to halt the environmental degradation that threatens the long-term integrity of the Pan Amazon.

Looking forward, multiple interrelated phenomena will determine the future of the region: some would support the development of a sustainable economy, while others would reinforce the behaviors linked to conventional business models. Quite a few are neutral in nature and have impacts that could be mitigated in a well-managed and diversified regional economy. They can be organised in the following four categories, based on their probability of occurrence and their potential to contribute to a sustainable future (Chapter 13).

Things that will definitely happen

Highway networks will continue to expand; existing roads will be upgraded; it is just a matter of time. Agricultural enterprises with overseas export markets will expand; this will displace some producers toward the forest frontier (ranchers) and motivate others to expand existing production models (smallholders). The extractive industries will dominate the economies of jurisdictions rich in mineral resources; their environmental performance will improve, but they will still create long-term environmental liabilities. Sustainable production technologies, such as aquaculture, will provide new economic opportunities, while selected forest products, such as *açaí*,

Río Branco, the capital of Acre, is home to approximately 50% of the state's citizens, a rural–urban distribution replicated throughout the Southern Amazon where three of every four inhabitants reside in towns with a population greater than 10,000. Many urban residents support nature conservation, but their economies are dependent on production systems linked to deforestation and the extractive industries.

will become new export commodities. Initiatives to decentralise the administrative functions of the state will empower both local elites who want to expand conventional production models and grassroots activists who advocate for environmental conservation and social justice. Urbanisation will continue to expand the opportunities and improve the living conditions of the region's inhabitants.

Things that might possibly happen

The management of protected areas should improve as their operations are incorporated into state budgets; nonetheless, political opposition may cause some to be downgraded or degazetted from the system. Indigenous communities will face challenges to protect their land; some may be tempted to sell access to natural resources in exchange for money. Widespread non-compliance with the land-use zoning regulations (e.g., Forest Code) and the

loss of forest remnants may diminish the convective systems that maintain high precipitation regimes. Consumer demand for deforestation-free commodities should lead to the intensification of production on agricultural landscapes, while community-based business models could improve the management of wild fisheries and decrease levels of informality (illegality) in the timber industry. Nature and cultural tourism could improve the livelihoods of traditional forest communities but would require significant investment in infrastructure, human capacity and marketing. Democratic reform and regulatory oversight can improve the quality and objectivity of environmental and social review but are unlikely to eliminate ill-advised investments in infrastructure or the extractive sector. Financial resources from PES schemes could provide critical support for the operational budgets for protected areas and indigenous lands but may not provide sufficient investment capital to reform non-sustainable business models.

Things that should never happen

There should be no new trunk highways constructed through any wilderness area; there are no justifications based on economic criteria within the transportation sector. Large-scale hydropower facilities on major rivers should be eliminated from consideration due to irremediable impacts on sediment flows and fish migration; they are rarely economically viable using standard financial criteria. Global warming should not exceed 2° Celsius due to impacts on plant physiology, forest carbon dynamics and continental-scale modifications of precipitation regimes.

Things that absolutely need to happen

The most pernicious and destructive activities in the Pan Amazon are all blatantly illegal, and governments must take action to bring them under control. Some are obvious by-products of a cultural tolerance of corruption: illegal logging and land grabbing. Others are the product of inequality and the lucrative nature of the illicit activity: artisanal gold mining and the cultivation of coca. Eradicating the former will require institutional reform and sustained law enforcement action; the latter will require a more integrated approach because of the number of people involved and their willingness to confront the state with violence.

Current Policy Approaches: Certainly Necessary, but Are They Sufficient?

The consensus strategy for saving the Amazon is based on a pentad of self-reinforcing policies: (1) create protected areas and recognise indigenous reserves; (2) improve governance to combat illegal activities; (3) increase

market demand for deforestation-free commodities; (4) enhance the economic value of forest livelihoods; and (5) generate financial revenues from PES schemes to underwrite the implementation of the first four strategic pillars. Two of these policies (3 and 5) rely on macroeconomic incentives, and two (1 and 2) on top-down initiatives emanating from central governments. Only one (4) seeks to change the microeconomics on the forest frontier, and it focuses on a part of the Amazonian economy that does not directly cause deforestation. All of these policies are reliant on REDD+ and, consequently, the development of a robust global carbon market.

This is not an unreasonable expectation. REDD+ provides an opportunity to mitigate global warming as well as alleviate the biodiversity crisis by subsidising policies that are cost-effective, timely and humane. REDD+ has always been viewed as an interim solution that would reduce emissions while the advanced economies, led by the United States, transition to a green economy. Unfortunately, the twenty-year delay in implementing a coherent climate change strategy has made REDD+ a less relevant policy tool.

It is increasingly likely that the Biden administration elected in 2020 will adopt a more aggressive climate change strategy that will reverberate across the global economy. Policies favoured by progressives call for a multi-sector investment and regulatory program that will rapidly transform the domestic economy.[22] In contrast, mainstream economists prefer a fiscally neutral carbon tax that will allow the market to determine which energy systems and technologies prevail.[23] Neither policy approach envisions a mandatory cap-and-trade system.[*] Moreover, many climate activists view REDD+ as 'greenwash' that would delay fundamental changes needed to create a zero-carbon economy, a view reinforced by the uncertainty in the permanence and additionality of forest carbon offsets originating in societies characterised by poor governance.[24]

Considering the large investment made by multilateral development agencies and tropical forest nations, some type of REDD+ mechanism will be implemented. Unfortunately, that system is more likely to remain – as it currently is – a mechanism for channeling overseas development assistance to developing nations combined with a voluntary carbon market used by corporations to offset emissions from fossil fuels (Chapter 10). That type of REDD+ system would provide essential support for protected area management and assist indigenous communities but it will not be sufficient to transform the economy of the Pan Amazon.

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* In June 2020, there were eight different legislative proposals before the US Congress to adopt policies to put a price on carbon; all but one are based on a carbon tax; the cap-and-trade bill is referred to as a cap-and-dividend system where revenues are returned to taxpayers and does not include a provision for carbon offsets created via the REDD+ mechanism. See: Price On Carbon, https://priceoncarbon.org/business-society/history-of-federal-legislation-2/

The need for a Plan B: Tree-based production systems

To be truly successful, the transformation of the Amazonian economy will require the wholesale support of the ranchers and smallholders who occupy eighty million hectares of previously deforested land and an approximately equivalent area at risk to future deforestation. Most landholders pursue business models based on deforestation, none of which are particularly productive when viewed from the perspective of energy (carbohydrates) or nutrition (protein). They are, however, economically advantageous when viewed within the timeframes that constrain investment decisions, even when those decisions lead to the eventual degradation of soil resources (Chapter 3). If the economic logic that drives deforestation were reversed – if planting trees were more lucrative than cutting them down – most landholders would happily change their production systems. This supposition is essentially the business model for agroforestry, a tree-based production system targeted at smallholders, and for plantation forestry, a tree-based production system appropriate for larger landholdings (Chapter 8).

Both production models have been promoted by extension agents and foresters for decades. The most notable examples of agroforest crops are coffee and cacao, while plantation systems include palm oil and wood fibre (cellulose, charcoal, biofuel or timber). Agroforestry systems are relatively popular among environmental advocates and the smallholders that adopt them. Plantation systems, however, typically attract the wrath of environmental activists because they have been associated historically with large-scale deforestation and are usually predicated on the monoculture of non-native species (Chapter 3).

The preferred option of most conservation scientists is the restoration of forest landscapes using native species to recreate natural habitat that would produce, eventually, high-quality hardwood timber species. Unfortunately, that business model has a pay-back time measured in decades, rather than years, and is nonviable without very large subsidies, which presumably would be provided by global carbon markets. In Brazil, environmental advocates contend that landholders will eventually be forced to restore native habitat in order to come into compliance with the Forest Code (Chapter 7). Perhaps – but recent history has revealed the social friction associated with that policy pathway, and it certainly will not happen during the administration of Jair Bolsonaro.

Tree-based production systems have the advantage of restoring atmospheric water-recycling functionality to highly fragmented, deforested landscapes (Chapter 10). Amazonian producers can be persuaded to adopt tree-based production models, but only if there is a genuine demand for the commodities they produce. Several million hectares of new coffee and cacao plantings would almost surely swamp global commodity markets

and destroy the economic incentive for cultivating them. In contrast, the production of wood fibre has a much larger growth pathway, particularly in light of the recent global awakening of the impacts caused by our plastic-based consumer economy. If fossil-fuel derived plastics were replaced by plant fibre, the potential economic opportunity for the Pan Amazon and other tropical forest regions would be enormous.

Tree-based production systems are not without risk, including the potential to displace cattle ranches to the forest frontier and the introduction of exotic species into natural habitats. Displacement risks could be mitigated using the same pentad of policy options described above, while the risk from invasive species could be avoided by using mixed plantings of native species, of which there are literally thousands of prospective candidates (Chapter 9). The pursuit of tree-based production systems based on a commodity with a global market represents yet another macroeconomic solution, but one using a business model that responds to the microeconomic challenges and social obstacles that have stymied current policies.

Açaí is a super fruit that has exploded in popularity over the last decade due to its nutritional benefits. It has been a staple of Amazonian commerce for centuries where it is harvested from a palm (Euterpe oleracea) that dominates floodplain forest in the lower Amazon. Landholders have started growing the açaí palm in plantations in order to meet global demand for exports that exceeded one billion dollars in 2019.

The Pan Amazon is a big, complicated region, and no single policy package will resolve the conundrum of reconciling nature conservation and economic development. Many, perhaps all, solutions will need to be local or regional in nature. Even the macroeconomic and top-down models favoured by policy specialists will need to be implemented in the context of geographically specific circumstances. This book attempts to lay these issues out in a systematic and logical narrative to facilitate the discovery of a pathway through a perfect storm of environmental mayhem to a sustainable future for the Pan Amazon and all of its inhabitants.

Annex 1.1: The relative contribution of the various sectors and subsectors to to the GDP of the Amazonian jurisdictions of the Andean republics (Left) and the Guiana coast (Right)

Agriculture & Forestry: Agriculture (AG), Fisheries & Aquaculture (FA), Forestry (FO), Livestock (LI);
Industry: Extractives (EX), Manufacturing (MA), Construction (CN);
Services (Private Sector): Real Estate (RE), Commerce (CO), Transportation (TR), Hospitality (HO), Telecommunications (TE), Finance (FI), Professional Services (PS), Other services (OS);
Services (Public sector): Public Administration (PA), Utilities (UT); Space Center (SP)
Illicit Activities: Coca/Cocaine (CC), Artisanal Gold (Au)

Annex 1.2: The relative contribution of the various sectors and subsectors to the GDP of the states of the Brazilian Amazon

Agriculture & Forestry: Agriculture (AG), Fisheries & Aquaculture (FA), Forestry (FO), Livestock (LI);
Industry: Extractives (EX), Manufacturing (MA), Construction (CN);
Services (Private Sector): Real Estate (RE), Commerce (CO), Transportation (TR), Hospitality (HO), Telecommunications (TE), Finance (FI), Professional Services (PS), Other services (OS);
Services (Public sector): Public Administration (PA), Utilities (UT); Space Center (SP)
Illicit Activities: Coca/Cocaine (CC), Artisanal Gold (Au)

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