# Ecosystems and biodiversity in the face of climate change

3

- The importance of ecosystem services for human life and their role in climate change adaptation and mitigation strategies
- Ecosystems in Latin America and the Caribbean, main services they provide, causes of their degradation, and associated economic sectors
- Main ecosystem preservation and restoration policies. Key factors for their effectiveness.

# Key messages

**1**

The services that ecosystems provide make human life possible. They include food, fresh water, medicines and materials, regulating and maintaining the environment, and acting as a source of inspiration and identity.

**2**

Ecosystem conservation and restoration is also key to climate change response. Ecosystems provide indispensable mitigation services, capturing carbon from the atmosphere, and adaptation services, providing protection against extreme climate events.

**3**

There is a close and tense relationship between ecosystems and economic activity. Economic activity makes use of ecosystems and modifies the services they provide, favoring those that can be commercialized (e.g., food production) at the expense of those that cannot (e.g., climate regulation).

**4**

Human activity degrades nature through four direct channels: land use change, overexploitation of (natural) resources, pollution, and the introduction of invasive species. In the region, land use change is the main channel of ecosystem degradation, followed by overexploitation.

**5**

The agricultural sector is strongly linked to land use change: it has grown from 15% in 1900 to 51% of the region's land area. This sector serves multiple needs, such as food, construction materials, fibers for clothing, and energy in the form of charcoal and biofuels.

**6**

Nature-based solutions are cost-effective actions to address societal challenges by protecting and sustainably managing ecosystems. For example, the preservation of mangroves, coral reefs and salt marshes, which not only provide crucial flood protection services to coastal communities but also play a vital role in supporting artisanal fisheries and sequestering $CO_2$ emissions.

**7**

Protected areas play an essential role in safeguarding species, ecological processes, and vital ecosystem services. Latin America and the Caribbean's extensive coverage of these areas, encompassing 22% of both terrestrial and marine surfaces, is notable. Ensuring a comprehensive representation of all the biomes and effective protection remains a pending challenge in the region.

**8**

The co-management of multiple-use protected areas and other publicly owned natural resources with local communities and other stakeholders allows for a balance between conservation objectives and local development. Local communities can play a key role in preserving ecosystems, some of which they have inhabited for centuries.

## 9

Latin America and the Caribbean has more than 250 programs of payments for ecosystem services, which are voluntary participation schemes that compensate those who conserve and restore ecosystems. These programs need to be carefully designed to ensure a positive impact (on the environment).

## 10

The region is a leader in the adoption of eco-certifications, primarily for bananas, coffee, and cacao. These certifications aim to provide consumers with information about the environmental impact of products and channel their demand toward effective incentives for conservation. The evidence regarding the impact of eco-certification is still emerging and requires further development.

## 11

Industry agreements to avoid purchasing products or services that do not comply with environmental safeguards are an alternative to promote the adoption of sustainable practices. An exemplary case is the “Soy Moratorium” agreement in Brazil, which reduced deforestation in the Amazon.

## 12

Non-discriminatory subsidies to the agricultural and fishing sectors can contribute to the deterioration of ecosystems and biodiversity. The elimination and reform of subsidies that harm biodiversity have been included in the 2030 targets of the Global Biodiversity Framework.

# Ecosystems and biodiversity in the face of climate change[1]

## Ecosystem services: key to climate change response and human development

### The services that nature provides to people

The ecosystems provide vital services to human existence. These benefits, known as ecosystem services, encompass the provision of food, freshwater, medicine, and materials. Moreover, they play a crucial role in regulating and maintaining the environmental components that shape our living environment and serve as a wellspring of inspiration and a source of cultural identity (see Box 3.1). The quality, intensity and type of available ecosystem services are indispensable for human development (Millennium Ecosystem Assessment, 2005; PBES, 2019).

Ecosystem services for climate regulation are crucial to tackle climate change. As discussed in Chapter 1, ecosystems play a vital role in mitigating climate change by absorbing carbon dioxide from the atmosphere and storing it in biomass and soils. In LAC, the Amazon rainforest alone holds a carbon stock equivalent to nine years of global fossil fuel emissions (Baccini et al., 2012; Ferreira, 2023). Furthermore, ecosystems contribute to climate change adaptation by moderating extreme weather events and regulating local climate patterns. For instance, mangroves and coral reefs serve as protective barriers, reducing the risk of coastal flooding and shielding Caribbean communities from the escalating frequency of hurricanes attributed to climate change.

Beyond their climate-related functions, ecosystems also govern other fundamental processes essential to human life. These include maintaining air quality through the removal of pollutants from the atmosphere, purifying water by utilizing microorganisms that break down waste and eliminate

1 This chapter was prepared by Ricardo Estrada and Federico Juncosa, with research assistance from Matías Garibotti.

pathogens and preserving soil quality by preventing erosion through vegetation coverage. Ecosystems are also responsible for pollination of plants and trees, including crops, through the interactions of insects, birds, and bats. They contribute to pest control by harnessing the power of natural predators and parasites, while also influencing the water cycle through water capture, evaporation, and infiltration, with forests playing a particularly significant role (Millennium Ecosystem Assessment, 2005).

**Ecosystem services are the benefits nature provides for people, such as food, medicine, regulating the environment, and being a source of inspiration and cultural identity**

**Box 3.1**
Ecosystem services

An ecosystem is a “dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit” (CBD, 1992). The definition of a specific ecosystem depends on the question of interest, and therefore its scale can vary significantly. For example, the entire planet’s biosphere constitutes a large ecosystem, encompassing multiple ecosystems of different levels (Millennium Ecosystem Assessment, 2005). In this report, ecosystems are grouped, in their most aggregated form, into terrestrial, coastal, and marine ecosystems. Forests are an example of terrestrial ecosystems, which in turn consist of several ecosystems with relatively precise geographical boundaries, such as the Amazon rainforest.

The concept of ecosystem services refers to all the benefits that nature provides to people and is part of the conceptual framework proposed by the Millennium Ecosystem Assessment (2005). Ecosystem services can be categorized as regulating, provisioning, cultural, and supporting services.[a]

Regulating services refer to the benefits people derive from the regulation of ecological processes, including climate regulation, air purification, erosion control, and disease control.

Provisioning or material services are the goods people obtain from ecosystems. These include food, freshwater, fuels, materials, and genetic resources. The elements that provide these services are typically physically consumed in the process of their use.

Cultural or non-material services are the benefits that ecosystems provide to people— individually and collectively—through spiritual enrichment, cognitive development, recreation, and aesthetic experiences.

Lastly, supporting services are those necessary to produce all other ecosystem services. Examples include oxygen production and soil formation.

[a] The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) introduced the concept of nature’s contributions to people, which, although closely related to ecosystem services, has some distinct differences. Unlike ecosystem services, it includes both the positive and negative impacts of nature on people and acknowledges the role of human-modified ecosystem services (IPBES, 2018). For the purpose of this report, the term “ecosystem services” is used.

The state of ecosystems determines the flow of services they provide. Biodiversity—which refers to the diversity of life in all its forms—is a crucial aspect of this condition. It not only influences the flow of ecosystem services but also the resilience of ecosystems, i.e., their ability to maintain their properties, key functions, and processes in the face of external disturbances and to recover once the disturbance ceases. Therefore, preserving biodiversity is key to the health of ecosystems and the services they provide (see Box 3.2).

Economic activity, like all human activities, depends in one way or another on ecosystem services. In some cases, such as provisioning services, this relationship is evident. For example, the development of the fishing industry in Peru, Chile, and Mexico (the largest in the region) has been possible due to the richness of commercially valuable species in the coastal and marine ecosystems of these countries. Something similar occurs with cultural services. The beauty of beaches and coral reefs has been crucial for the boom in the tourism sector in Caribbean countries. In the case of regulating services, the relationship between ecosystems and certain economic activities, although close, may be less obvious, either due to the geographic scope of the services in question or the subtlety or complexity of the underlying ecosystem processes. For example, the agricultural industry in Argentina, Paraguay, Uruguay, and southern Brazil benefits from the abundant water vapor flows (known as flying rivers) that form hundreds of kilometers away in the Amazon rainforest. Agricultural productivity also benefits from the services provided by natural pollinators, among which insects play a prominent role. Bees pollinate a wide variety of crops in the region and contribute to the profitability of the industry, either due to the high dependence of certain crops on bee pollination (such as cocoa, pumpkin, and other vegetables) or because, although less dependent, they are crops with high production levels (such as soybeans) (Basualdo et al., 2022).

## Economic activity and ecosystem degradation

Human activity changes the basket of services obtained from nature (Dasgupta, 2021). ). For example, deforestation allows for the expansion of agricultural land, but at the cost of reducing other services provided by forests (such as climate regulation, water purification, the supply of timber and medicinal plants, etc.). Generally, the modification of ecosystems favors services that generate greater private benefits, such as provisioning services, more than those for which there are no markets to trade them.

Ecosystems are resilient, but this resilience has limits. As explained in Box 1.2 of Chapter 1, there are tipping points beyond which ecosystem degradation and the loss of their services become irreversible.

**Ecosystems are resilient, but their strength is limited. They can reach a tipping point beyond which their degradation and the loss of the services they provide can be irreversible**

The growth of the world economy and the global population over the last few decades is the main driver behind the unprecedented increase in the demand for food, materials, and energy. This increase has resulted in a significant alteration of ecosystems, leading to biodiversity loss and the weakening of the services they provide (IPBES, 2019; Millennium Ecosystem Assessment, 2005). In Latin America and the Caribbean, the expansion of agricultural and livestock activities is the main reason why the region's natural or semi-natural land area decreased from 85% in 1900 to 45% in 2017.

## Box 3.2
### Connecting biodiversity to ecosystem services and ecosystem resilience

The Convention on Biological Diversity (CBD) defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (CBD, 1992).

Biodiversity is a key determinant of the variety and level of the services ecosystems provide, as well as their resilience to external disturbances. A notable manifestation of this relationship is that the carbon cycle is largely a result of life on Earth and depends on preserving certain key relationships among species communities. For example, the loss of large fruit-eating mammals, such as tapirs, reduces seed dispersal that is crucial for the growth and survival of the Amazon rainforests and, consequently, their carbon capture potential (Peres et al., 2016). The presence and complementarity of species with different functions determines the productivity of ecosystems services. (Dasgupta, 2021).

In turn, the diversity of species with similar functions, i.e., within the same functional group, determines ecosystems' resilience to disturbances. For instance, when an ecosystem is affected by atypical climatic conditions or the incidence of a pest, the diversity of species within the same functional group increases the chances that some species will show greater tolerance to the disturbance. Thus, the more tolerant species can replace the affected species, fulfilling a similar function in the ecosystem and enabling its subsistence. The range of possible reactions to environmental changes by species that share ecosystem functions is known as response diversity (Dasgupta, 2021; Elmqvist et al., 2003). Similarly, genetic diversity within the same species also contributes to its resilience and that of the ecosystems it inhabits.

**In LAC, the expansion of agricultural and livestock activities is the main reason why the region's natural or semi-natural land area decreased from 85% in 1900 to 45% in 2017**

The material gains obtained from economic activities that degrade ecosystems come at the cost of losses in ecosystem services, compromising the long-term sustainability of those gains. For example, deforestation for crop cultivation reduces pollinator populations and increases soil erosion, eventually resulting in agricultural yield losses. Unsustainable practices in industries such as fishing and logging have also diminished the availability of natural resources on which they depend. Pollution from the agricultural, industrial, mining, and tourism sectors has contributed to further ecosystem deterioration. Agriculture, along with trade and international travel, has introduced non-native species into local ecosystems, disrupting their balance and functioning. These impacts of economic activity on ecosystems and biodiversity are compounded by the impacts of climate change (Blackman et al., 2014; IPBES, 2019; Millennium Ecosystem Assessment, 2005).

Ecosystem degradation disproportionately affects rural communities and indigenous peoples, whose livelihoods depend more heavily on the services provided by nature in their surroundings. There is also a growing recognition of the role of traditional communities in shaping and conserving ecosystems (Gauthier et al., 2021).

●●

**Ecosystem degradation disproportionately affects rural communities and indigenous peoples, whose livelihoods depend more heavily on the services provided by nature in their surroundings**

From an economic theory perspective, externalities are a key concept for understanding the challenges of ecosystem and biodiversity conservation. Externalities are the secondary effects that the actions of an individual or group have on the rest of society. Externalities can be positive or negative and can range from local to global in scope. Carbon sequestration by trees planted to prevent erosion is an example of a positive global externality, while water pollution from fertilizer use is an example of a negative local externality.

Conservation and regeneration of ecosystems generate positive externalities in the form of ecosystem services, for which individuals and communities that provide them do not receive payment. This is due to the absence of markets for the trade of regulating services, such as natural pollinators. The lack of compensation does not mean that conservation and regeneration efforts are costless, as they often require reallocating resources (e.g., land) that could be used for producing goods or services that could be sold in existing markets (e.g., food). The gap between social and individual benefits leads to a suboptimal preservation of ecosystems for society as a whole.

The conservation of ecosystems and biodiversity has a relevant intergenerational dimension. Present deforestation and overexploitation of natural resources increases the current provision of food, raw materials, and energy provision. However, these practices compromise the capacity of ecosystems to provide a similar flow of services in the future and exacerbate the long-term effects of climate change. In other words, biodiversity loss compromises the welfare of future generations.

There is limited understanding regarding the functioning of ecosystems and the multitude of services they offer.(Maldonado and Moreno-Sánchez, 2023). This is reflected, for example, in the insufficient data that national accounts systems issue on the environmental status of the country (see Chapter 5). Agriculture producers also suffer from the scarce information available when trying to adopt sustainable practices (see Chapter 2). Closing these information gaps requires research, systematization, and dissemination efforts.

●●

## Ecosystems and biodiversity loss constitutes a negative externality for future generations

The negative impact of economic activity on ecosystems and biodiversity in Latin America and the Caribbean has become more severe. This is due to the implementation of public policies aimed at promoting economic development without a sustainability vision and the lack of institutional capacities to adequately define and enforce legislation for the protection of ecosystems and biodiversity and property rights over natural resources. The sub-section "Causes of ecosystem degradation and associated economic sectors" analyzes the channels through which economic activity degrades ecosystems and the factors behind this dynamic.

In summary, the impact of human activity on ecosystems and biodiversity compromises the ecosystem services they provide. A sustainable development strategy should promote sustainable use of ecosystems and ensure that nature contributions to current human development hold in the future. Despite recent extensive modifications, the region still possesses a vast wealth of ecosystems and biodiversity. The final section of this chapter addresses a series of policies for the preservation and regeneration of this wealth, as well as for enhancing its role in climate change adaptation and mitigation.

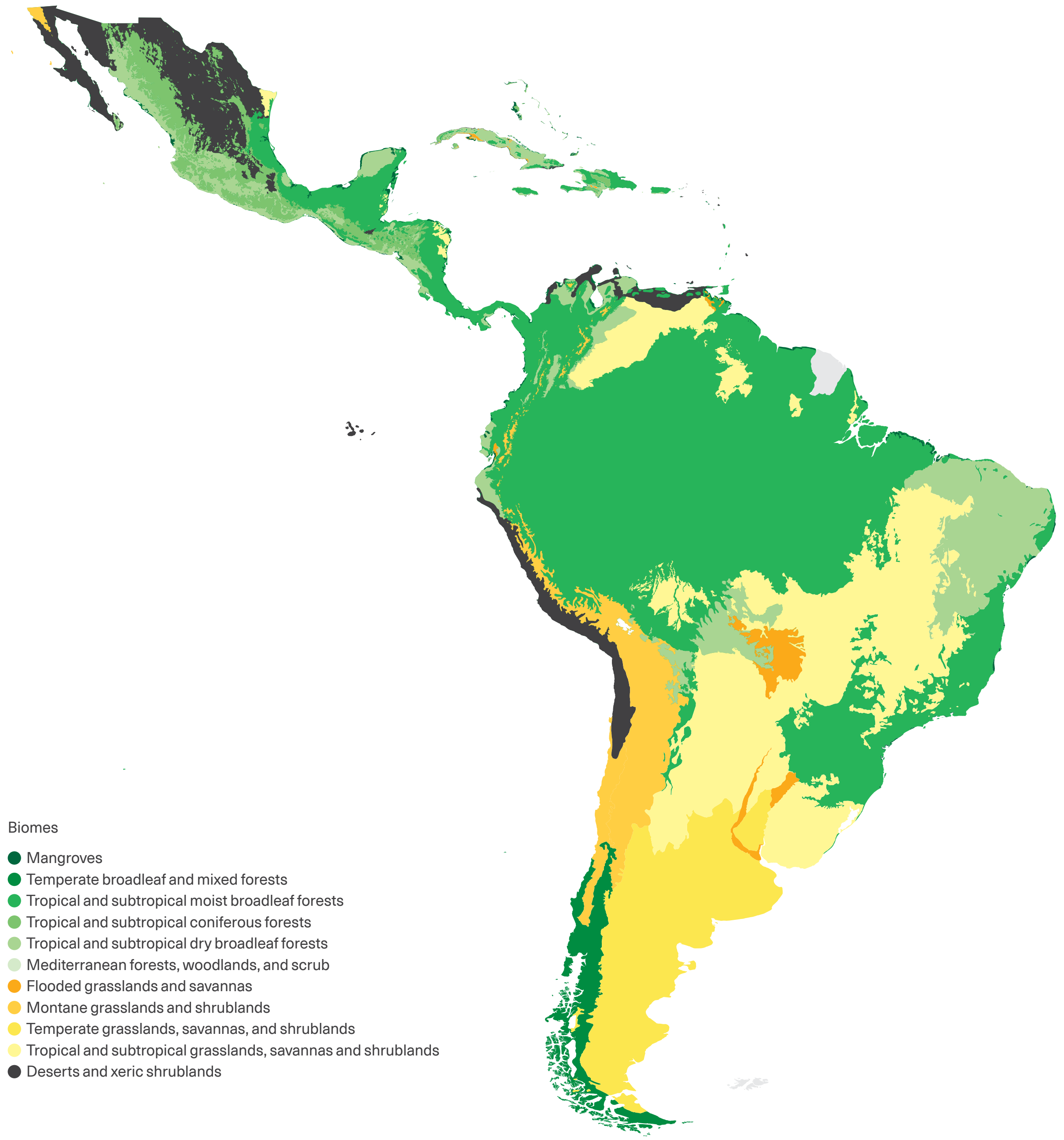
# Ecosystems and biodiversity in Latin America

## A region enriched by its remarkable biodiversity

Latin America and the Caribbean is an exceptionally rich region in terms of ecosystems and biodiversity. Its terrestrial ecosystems range from desert environments, where rainfall is scarce, to forests with the highest precipitation on the planet, as well as grasslands, savannas, and wetlands. With a land area of 20.04 million $km^2$, representing 16% of the global total, the region hosts an enormous variety of known species in the world: 33% of mammals, 35% of reptiles, 41% of birds, and 50% of amphibians (UNEP, 2011). The region's marine ecosystems—which cover an area of 16 million $km^2$ and over 70,000 km of coastline (Tambutti et al., 2022)—are also characterized by prominent biodiversity (Maldonado and Moreno-Sánchez, 2023).

A simple description of LAC's ecoregions and biomes demonstrates that the region's terrestrial ecosystems are outstandingly diverse (Dinerstein et al., 2017; Olson et al., 2001). Ecoregions are areas that host a distinctive group of natural species, which maintain functional relationships among them. The geographical limits of the ecoregions approximate to the extension of the area prior it had gone through significant land use changes. Ecoregions are grouped into biomes based on the predominant vegetation type and the latitudinal and rainfall gradients. Each biome is an extensive spatial unit that can encompass multiple types of land cover. For example, the tropical and subtropical humid forest biome includes not only forests but also areas covered by grasslands, wetlands, and bodies of water, among others. Graph 3.1 shows the terrestrial and coastal biomes present in the region.

**Graph 3.1**
Distribution of terrestrial biomes in Latin America and the Caribbean




**Note:** The map shows the different biomes present in LAC, according to the definition of Dinerstein et al. (2017).

**Source:** Authors based on data from Ecoregions2017 (Dinerstein et al., 2017).

Because ecoregions are delimited to capture distinctive ecological processes, the number of ecoregions present in a biome or region is indicative of its biodiversity value. Table 3.1 shows the distribution of the biomes of Latin America and the Caribbean by subregion (insular Caribbean, Mesoamerica, and South America) and the number of ecoregions in each.

The Caribbean subregion encompasses 22 distinct ecoregions, distributed among 18 countries that comprise over 7,000 islands and cays. It has a land area of 227,000 km$^2$, which expands to 2.7 million km$^2$ when considering the surface area of its marine platform. Its natural conditions of isolation and the presence of mountainous islands favor high species endemism and confer unique characteristics to its biodiversity. Most of the islands are surrounded by coral reefs, which are essential for the reproduction of commercial fish species and support tourism activities.

The Caribbean islands are collectively considered one of the five most important biodiversity hotspots[2] on the planet due to their unique diversity (Myers et al., 2000). The subregion has 11,000 plant species, of which almost three-quarters are endemic (i.e., only found in natural conditions there), while over 12,000 species have been reported in marine areas (Brown et al., 2019; Miloslavich et al., 2010). In the deep-sea areas of the Caribbean Sea, over 1,500 marine species have been documented (Costello et al., 2010).

**Table 3.1**
Ecoregions and area of major biomes by subregion

| Biome | Caribbean (227 kkm$^2$) | | Mesoamerica (2.34 Mkm$^2$) | | South America (17.7 Mkm$^2$) | |
|---|---|---|---|---|---|---|
| | Ecoregion No. | Area % | Ecoregion No. | Area % | Ecoregion No. | Area % |
| Tropical and subtropical coniferous forests | 3 | 11.2% | 7 | 22.6% | 0 | 0.0% |
| Tropical and subtropical moist broadleaf forests | 7 | 39.7% | 18 | 23.3% | 54 | 47.4% |
| Tropical and subtropical dry broadleaf forests | 6 | 37.2% | 12 | 17.9% | 15 | 8.6% |
| Temperate broadleaf and mixed forests | 0 | 0.0% | 0 | 0.0% | 2 | 2.1% |
| Mediterranean forests, woodlands, and scrub | 0 | 0.0% | 2 | 0.6% | 1 | 0.8% |
| Deserts and xeric shrublands | 2 | 2.0% | 11 | 32.3% | 7 | 2.3% |
| Mangroves | 2 | 7.0% | 4 | 1.5% | 3 | 0.2% |
| Mountain grasslands and scrublands | 0 | 0.0% | 0 | 0.0% | 9 | 4.9% |
| Flooded grasslands and savannas | 2 | 2.7% | 0 | 0.0% | 5 | 1.3% |
| Temperate grasslands, savannas and shrublands | 0 | 0.0% | 0 | 0.0% | 4 | 9.2% |
| Tropical and subtropical grasslands, savannas, and shrublands | 0 | 0.0% | 3 | 1.4% | 8 | 22.6% |
| Total | 22 | 100.0% | 57 | 100.0% | 108 | 100.0% |

**Note:** The table shows the number of ecoregions that each biome has in the LAC subregions according to the Ecoregions 2017 geospatial database. Between parentheses, under the name of each subregion, the total area is mentioned in thousands (kkm$^2$) or in millions (Mkm$^2$) of km$^2$. The Ecoregions2017 data were combined with the Global Administrative Areas geospatial database to assign the biomes to each country and region. The countries included in each subregion can be found in the appendix of this chapter available online.

**Source:** Authors using georeferenced data from Ecoregions 2017 (Dinerstein et al., 2017) and Global Administrative Areas (2012).

2 The term "biodiversity hotspot" refers to regions with a high concentration of biological diversity, which harbor at least 1,500 species of endemic vascular plants and retain only 30% or less of their original vegetation cover.

As shown in Table 3.1, the land area of this subregion is almost entirely within the humid and dry broadleaf forest biomes. Additionally, due to the extensive coastline area relative to its land area, it exhibits the highest relative presence of the mangrove biome. Mangroves cover approximately 7% of its surface and represent 16% of the total mangrove area in Latin America and the Caribbean (Vo et al., 2012).

Mesoamerica has intricate topography, which creates a wide range of environmental conditions. This favors, for example, high concentrations of small vertebrates (Jenkins et al., 2013) and endemic species (Myers et al., 2000). This subregion is of paramount importance for the biodiversity throughout the continent, as it connects species migration between the north and the south. The most significant migration patterns of birds between latitudinal gradients, for instance, critically depend on the natural and semi-natural areas of this subregion to accommodate numerous species during the subtropical winters of the north and south or during stopovers for feeding and resting en route to their final migratory destination (Declerck et al., 2013; Kirby et al., 2008). Box 3.3 highlights the importance of migratory birds to ecosystems across the continent.

**Box 3.3**

## Migratory Birds of Latin America and the Caribbean

The region is home to approximately 41% of all bird species identified in the world (BirdLife International, 2023). Birds play a crucial role in ecosystems due to their distinct characteristics compared to other vertebrates. Most bird species migrate over long distances, connecting distant ecosystem processes and quickly responding to variations in climate and water and food resources. Some of the most important ecosystem services provided by birds include plant pollination, soil fertilization, seed dispersal, and the control of pests and predators, which helps limit damage to crops and other ecosystems.

The accelerated degradation of the region's ecosystems has contributed to the fact that, at present, 559 bird species are endangered, representing over a third of globally endangered species (Audubon, 2022). Significant population losses extend beyond endangered species (Audubon, 2022; BirdLife International, 2023). The reduction in bird diversity and population size can have cascading effects on other plant and animal species, resulting in increased vulnerability and exposure of natural ecosystems and agricultural systems. The mass extermination of the Eurasian tree sparrow in China in 1958 serves as an illustrative example of the risks involved. Sparrows were eradicated due to their perceived negative impact on agriculture productivity. However, contrary to expectations, the elimination of sparrows led to a rapid decline in rice crop yields as pests, previously controlled by the sparrows, proliferated (Díaz-Siefer et al., 2022; Whelan et al., 2008, 2015).

Protecting bird populations requires a comprehensive understanding of their migratory cycles, and preserving their reproduction, rest and wintering habitats. In this regard, collaborative efforts between countries and international organizations such as BirdLife International and the International Union for Conservation of Nature (IUCN) identify and delineate globally significant ecosystems for endemic and endangered species. These are known as Key Biodiversity Areas (KBAs) and Important Bird and Biodiversity Areas (IBAs). This task is ongoing. In the region, the challenge lies in the fact that only around 40% of identified IBAs currently have some form of protection, and protected areas cover only 9% of migratory bird species (BirdLife International, 2023). Expanding protection to cover these areas will contribute to the recovery of both migratory and endangered bird populations, providing significant benefits to the wellbeing of the region.

One of the most representative biomes in Mesoamerica are the deserts and xeric shrublands, which cover 32% of the total area. Deserts and xeric shrublands are important because of their diversity and endemism (Goudie & Seely, 2011; Le Saout et al., 2013). For example, estimates show that 44% of seed plant genera are endemic to Mexico's drylands (Challenger and Soberón, 2008). Most of the remaining area is covered in roughly equal parts by moist and dry broadleaf forest biomes and coniferous forests. The coastal areas exhibit a substantial presence of mangroves, seagrasses, and coral reefs, with the Mesoamerican Barrier Reef being the second largest and most complex in the world, after Australia's Great Barrier Reef.

Lastly, South America's vast extension of 17.7 million $km^2$, which spans an ample range of latitudes and altitudes, enables the development of prominent biodiversity. The subregion is dominated by the moist broadleaf forest biome, which occupies almost half of its surface. The Amazon Basin represents approximately 90% of this biome and contains the largest coverage of primary forests (those whose ecological processes have not been significantly altered by human activity) on the planet, with exceptional biodiversity and levels of endemism.

Tropical and subtropical grasslands, savannas, and shrublands represent the second largest biome in South America in terms of land extension, covering 23% of the total area. It represents a majority portion in Uruguay and Paraguay and a significant portion in Venezuela, Brazil, Bolivia, and Argentina (in order of relative importance in each country). In turn, the desert and xeric shrublands and the mountain grasslands are especially diverse biomes, as they collectively host 15% of the identified ecoregions in the subregion, despite representing only 2.3% and nearly 5% of its surface area, respectively.

The diversity of ecosystems and species in Latin America and the Caribbean provides a multitude of highly valuable ecosystem services at local, regional, and global scales. Globally, some of these ecosystems play a prominent role in climate change mitigation, while at the regional and local levels, they provide important adaptation services that are crucial for the wellbeing of the region's population. The following analysis focuses on terrestrial, coastal, and marine ecosystems, as well as the key services they provide. In the case of terrestrial ecosystems, emphasis is placed on forests, grasslands, and wetlands, while for coastal and marine ecosystems, mangroves and reefs are highlighted due to their significance in climate change response and economic activity.

## Terrestrial ecosystems and their services

Terrestrial ecosystems play a fundamental role in carbon sequestration (see Chapter 1). However, the sequestration capacity varies across different ecosystems, leading to differentiated roles in climate change mitigation strategies.

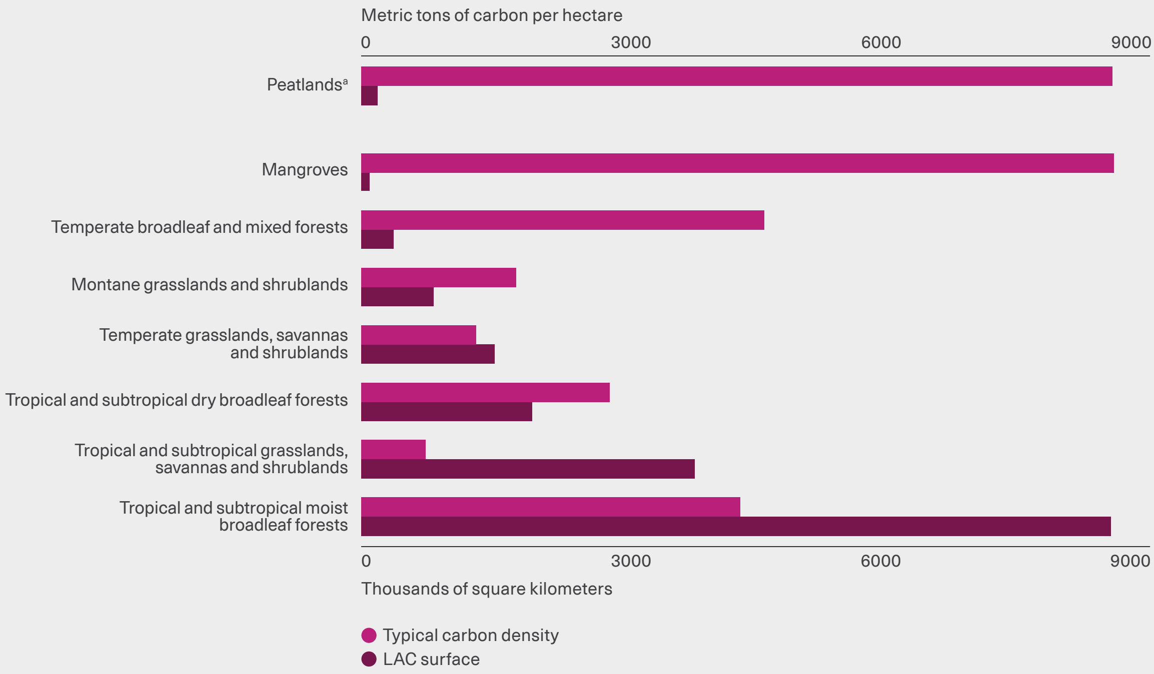
Box 3.4 presents a measure of the mitigation potential of biomes based on the classification used in this chapter and their extension in the region. The following discussion considers terrestrial ecosystems in three categories: forests; grasslands, savannas, and shrublands; and wetlands.

## Box 3.4
The carbon potential of terrestrial biomes in Latin America and the Caribbean

Different ecosystems play distinct roles in climate change response strategies. Each of the major biomes that classify the terrestrial surface has different carbon potential.[a] This concept refers to the carbon stock that a hectare (ha) of each biome can store on average when it is in good conservation condition and maintains its natural soil cover. The total carbon potential depends on the type of biome and its extension.

Graph 1 presents the carbon potential per biome and its extension in Latin America and the Caribbean, including both above- and below-ground biomass content and carbon in soils. Additionally, the graph presents the average carbon density in peatlands. These regions are waterlogged areas with high carbon content in their soils, usually located within moist broadleaf forests and flooded grasslands and savannas. The graph differentiates the carbon content of peatlands, which is additional to the carbon content of the biome they form part of.

### Graph 1
Typical carbon density and total area according to biome and ecosystem




**Note:** The graph shows, for each biome, the surface area it occupies in LAC expressed in thousands of $km^2$ (bottom axis) and the average carbon concentration per hectare in each of these biomes (top axis). The graph includes data for the 33 countries belonging to the Community of Latin American and Caribbean States (CELAC).

a. Peatland regions are included within the forest and grassland biomes; the reported value corresponds to the carbon stored in the soil as peat and is additional to the indicated carbon quantity for the respective biome.

**Source:** Authors based on Goldstein et al. (2020) and georeferenced data from Ecoregions2017 (Dinerstein et al., 2017).

The graph reveals marked heterogeneity in carbon potential. For example, while the humid broadleaf forest biome stands out for its extensive coverage in the region, it is not the biome with the highest carbon storage potential per unit area. Instead, peatlands have a smaller total area but exhibit the highest carbon density per unit area, exceeding 500 metric tons of carbon per hectare (mtC/ha).

In summary, forests hold the vast majority of carbon potential in the region. However, regions with peatlands and mangrove cover are particularly carbon-dense, which makes their conservation extremely important. Lastly, grasslands, savannas, and shrublands hold significant additional carbon potential. Furthermore, as will be discussed later, this biome shows greater resilience to the disturbances caused by climate change, indicating a potentially increasing role in certain countries.

[a] Chapter 1 discusses the capacity of different forest types in the region to contribute to net carbon capture. In this box, however, the carbon potential is presented by biome, along with the respective coverage or extent of each biome in the region.

## Forests

The forests of Latin America and the Caribbean play a central role in the wellbeing of the region due to the ecosystem services they provide, their contribution to climate change mitigation, and their significance to the culture and identity of communities. Among the most important local services forests offer are the provision of food and materials, local climate regulation, and air and water purification.

Forests host prominent biodiversity. This is associated with the structural complexity of forest cover, including the horizontal and vertical variability of tree canopies, which enables a greater diversity of species to thrive (Davies and Asner, 2014; Penone et al., 2019). Primary forests are particularly especially valuable as they exhibit qualitative differences and significantly higher diversity compared to secondary forests (those in recovery after human disturbance) and forest plantations (Barlow et al., 2007) .

**Primary forests are especially valuable as they exhibit qualitative differences and significantly higher diversity compared to secondary forests and forest plantations**

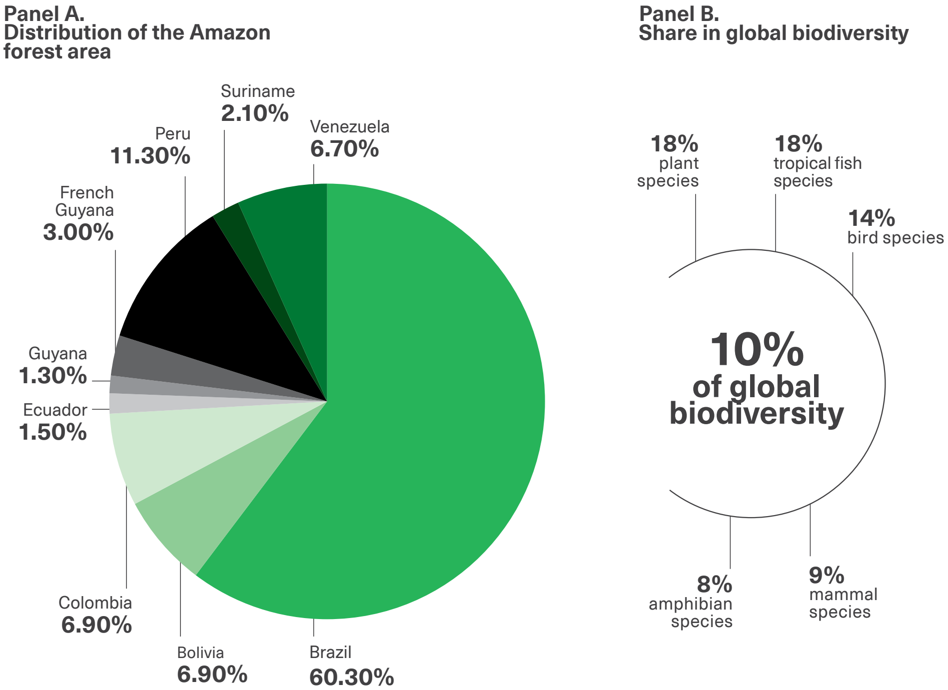
The richness of forests in species diversity and abundance contributes to the nutrition and health of people. Forests provide non-timber forest products used for food purposes (wild game meat, insects, fruits, and mushrooms), clothing and tools (animal skins, plant fibers), and health (medicinal plants, bacteria, and fungi). Medicinal products extracted from or based on research conducted in forests are of global importance. For example, among all approved drugs worldwide for the treatment of diseases between 1981 and 2006, 28% were natural products or derived from them, while 24% were synthesized drugs based on natural products (Cao and Kingston, 2009; Newman and Cragg, 2007).

Forests provide vital services for global and local climate regulation. As already noted, at the global level they contribute to climate change mitigation through carbon capture and storage. The total area of standing forests in Latin America and the Caribbean is estimated at 9.3 million km$^2$, which is equivalent to 46% of its territory[3] (Potapov et al., 2022). The total area of natural forest cover, i.e., forests that have never been intensively managed, is equivalent to 37% of the region (see Chapter 1).

Forest cover in the region is mainly featured by the tropical forests in the Amazon River basin, the Atlantic coastal forest, the tropical mountainous forests of the Andes, the lowland forests of Venezuela and the Guianas, and the temperate Patagonian forests of Argentina and Chile. Among them, the Amazon stands out as the largest tropical forest in the world, renowned for its prominent biodiversity. It is also traversed by the Amazon River, which stretches for 7000 km and is the longest and most voluminous river in the world (see Figure 3.1).

**Almost half of Latin America and the Caribbean territory is covered by forests**

**Figure 3.1**
The Amazon and its biodiversity




**Note:** The figure shows how the total territory of the Amazon is distributed among countries (panel A) and relevant data on the biodiversity of this forest (panel B).

**Source:** Authors based on Ferreira (2023); Guayasamin et al. (2021); Vergara et al. (2022); Zapata-Ríos et al. (2021).

3 This includes areas with a tree cover of over 30% and with an average canopy height of more than 30 meters. This is not equivalent to the area of forest biomes, which comprise an area of 12.1 million km² in LAC. There are standing forests outside the forest biomes and part of the cover of these biomes has no standing forest.

The Amazon plays a very important role in the regulation of the global climate due to the amount of carbon stored in its trees and soils (Pan et al., 2011) . It also serves as a central regulator of the water cycle in South America through its vast capacity for water storage and evaporation. The forest captures water from the Atlantic Ocean winds and stores it in its water bodies and vegetation. Through evaporation, clouds are formed, which, carried by the wind, generate rainfall across the Southern Cone (Spracklen et al., 2012) reaching as far as the northern United States. In this way, the Amazon contributes to agricultural productivity in the region and sustains human life (Ferreira, 2023).

**The Amazon forest has a carbon stock equivalent to nine years of global fossil fuel emissions**

### Grasslands, savannas and shrublands

Ecoregions characterized by a significant presence of natural grasslands encompass a broad set of ecosystems, from those with almost no trees, to savannas populated by scattered trees, and even to shrub regions with mosaics of grasslands and tree vegetation (Veldman et al., 2015). Grassland, savanna, and shrubland biomes are possibly the least prioritized in global conservation efforts. Part of the reason has been the lack of understanding regarding the origin and function of these ecosystems, as they are often misinterpreted as forests in early stages of formation or as degraded lands (Bond, 2016; Silveira et al., 2020).

Environmental conditions in grasslands, savannas and shrublands are diverse, ranging from highly arid climates where temperatures are extreme and forests cannot naturally grow, to regions featured by a continuous competition between forest and grassland cover. These ecosystems present a diverse set of environmental conditions, ranging from extreme climates characterized by high aridity and extreme temperatures incapable of sustaining forests naturally to regions defined by continuous competition between forest and grassland cover. Natural grasslands (or ancient grasslands) are the result of a combination of factors that limit the establishment of woody vegetation: extreme temperatures, monsoon precipitation regimes favoring natural fire events, and the presence of large herbivores (Bond and Parr, 2010; Veldman et al., 2015). Understanding the role of these factors is crucial for conservation efforts.

Grasslands are home to significant biodiversity, which, although lower in species and population numbers compared to forests, exhibits high endemism, with multiple species having adaptations to inhabit their specific characteristics (Bond and Parr, 2010; Parr et al., 2014). In addition to providing habitat for this diversity, grasslands offer a set of key and distinct ecosystem services. They include pollination services, which are important for surrounding crops; climate moderation services, as they reflect a greater fraction of solar energy (higher albedo) than forest cover and reduce heat absorption; and water infiltration services to groundwater, as they exhibit relatively low evapotranspiration compared to forest cover. Grasslands also have high potential for carbon capture and storage in the soil, which, unlike carbon stored in above-ground biomass, exhibits high stability and low risk of release during drought or fire events (Dass et al., 2018; Silveira et al., 2020; Veldman et al., 2015).

**Natural grasslands are a critical source of livelihood for the region's rural communities, which rely on them to feed cattle, sheep and goats**

The shrubland, savanna, and grassland ecoregions of Latin America and the Caribbean are mainly found in South America, covering over 5 million $km^2$. Among the most representative ecosystems are the Cerrado in Brazil, the Gran Chaco in Bolivia, Paraguay, and Argentina, the Pampas in Argentina, Uruguay, and southern Brazil, and Los Llanos in Colombia and Venezuela. However, there are also regions of natural grasslands in mosaic patterns within other biomes and in mixed agricultural-natural landscapes. Natural grasslands are a critical source of livelihood for rural communities in the region , as they provide sustenance for cattle, sheep, and goats. In turn, these species represent a key source of food and clothing for these communities.

## Wetlands

Freshwater inland wetlands (different from coastal ecosystems, that will be described later) are submerged expanses that are intermittently inundated due to seasonal precipitation, multi-year cycles, or tidal fluctuations. As water is the defining characteristic of these ecosystems, they are of vital importance for providing key ecosystem services such as supporting biodiversity, regulating the water cycle, and purifying water.

Water saturation of wetlands decreases soil oxygenation, slowing the decomposition of organic maters and thus increasing carbon capture and storage. Even more, when the decomposition rate in wetlands is slower than growth rate of new vegetation, peatlands with high organic carbon content in soil develop (Moomaw et al., 2018). Globally, these peatlands constitute one of the largest carbon stocks, estimated at 450 gigatonnes (GtC), occupying only 3% of the land surface (Joosten et al., 2016). It is estimated that Latin America and the Caribbean harbor between 4.4% and 12% of the global extent of peatlands.

While wetlands work as substantial carbon stores and have a capture capacity that does not decline over time, they are also naturally an important source of methane emissions. Methane is a much more powerful greenhouse gas than carbon dioxide, although it has a shorter atmospheric lifespan (around 10 years). Globally, freshwater wetlands are estimated to be responsible for one-fifth to one-fourth of global methane emissions, surpassing the combined emissions from fossil fuel extraction and use and landfills (Moomaw et al., 2018).

Due to this delicate balance between the large amount of stored carbon in natural wetlands, their $CO_2$ capture capacity, and their significant methane emissions, the most recent evidence points out that maintaining natural wetlands in good preservation condition is needed. In contrast, restoring degraded wetlands with low carbon content in the soil or the creating new wetlands (such as those formed by dam construction) can hinder climate change mitigation efforts by contributing to methane emissions (Taillardat et al., 2020).

### Wetlands provide important adaptation services, mainly by moderating water cycles

Wetlands also provide important adaptation services, mainly by moderating water cycles, absorbing abundant rainfall, and slowing its runoff in dry seasons .

Freshwater wetlands are home to a significant fraction of global biodiversity while providing transient habitat and food for numerous terrestrial animal species and migratory birds (Gopal et al., 2000). They also provide food and a reproductive habitat on which multiple fish species depend. The Amazon basin is home to over 3,000 identified fish species, the highest diversity among the basins in the region, followed by the Orinoco basin (1,000 species). Most wetlands in the region host endemic species with limited territorial distribution due to the environmental stability they provide compared to neighboring regions. Furthermore, this stability is believed to have provided refuge for numerous species during climatic fluctuations throughout geological eras (Wittmann et al., 2015).

Wetland-dominated ecoregions in Latin America and the Caribbean cover 760,000 km$^2$ (Dinerstein et al., 2017),[4,5] primarily located in three South American regions: the Amazon, where flooded forest ecoregions occupy 60% of the subregion's wetlands; the Bañados de Utuquis-Gran Pantanal system, covering 170,000 km$^2$; and the Paraná Delta, covering 17,500 km$^2$.

## The role of coastal and marine ecosystems

As described in Chapter 1, oceans play a central role in regulating global climate by absorbing heat and carbon from the atmosphere. Because water has a high capacity for storing heat, oceans capture a significant portion of the excess energy trapped by greenhouse gases, thus moderating the rise in temperature. Oceans are also important carbon sinks, primarily through a mechanism known as the solubility pump. This refers to the capture of carbon through gas dissolution and the subsequent formation and dissolution of salts. Additionally, thanks to their prominent biodiversity, oceans capture carbon through another mechanism known as the biological pump. This operates through the action of marine organisms that perform photosynthesis, converting inorganic carbon into biomass, some of which is stored in the depths of the ocean. Together, it is estimated that oceans have captured a quarter of total human carbon emissions (IPCC, 2022c).

The term blue carbon refers to carbon flows in marine ecosystems that can be managed for climate change mitigation (IPCC, 2022c). Currently, blue carbon policies focus on the restoration and conservation of vegetated coastal ecosystems: mangroves, seagrasses, and salt marshes. These ecosystems have a high carbon content relative to their surface area, although the overall mitigation potential of policies for their restoration and protection is estimated to be modest (Bindoff et al., 2019).[6] However, they can provide important co-benefits to coastal communities, in terms of adaptation to climate change and sustainability of the economic activities that depend on them. They are considered particularly valuable policies for climate change response in Mesoamerican and Caribbean countries that are highly dependable on coastal activities.

●●

**Mangroves, seagrasses, and salt marshes provide coastal communities with important benefits for adapting to climate change**

It is worth noting that the role of oceans in heath and carbon mitigation comes at the cost of significant negative consequences for coastal and marine ecosystems and the economic activities that depend on them. As discussed in Chapter 1, rising temperatures and sea levels, acidification, and increasing frequency and intensity of storms are the main channels through which climate change degrades these ecosystems. At the same time, the adaptation services provided by mangroves and coral reefs are becoming increasingly relevant.

The mangrove ecosystem is located on the marine coasts and estuaries, in the upper half of the intertidal zone. Graph 3.2 illustrates the mangroves along the region's coasts. The countries with the greatest extension of mangroves are Brazil and Mexico, with 11,300 km$^2$ and 9900 km$^2$, respectively,

4 Authors' estimate calculations based on data from Dinerstein et al. (2017). For more details on the calculation methodology used, see the online appendix of this chapter.

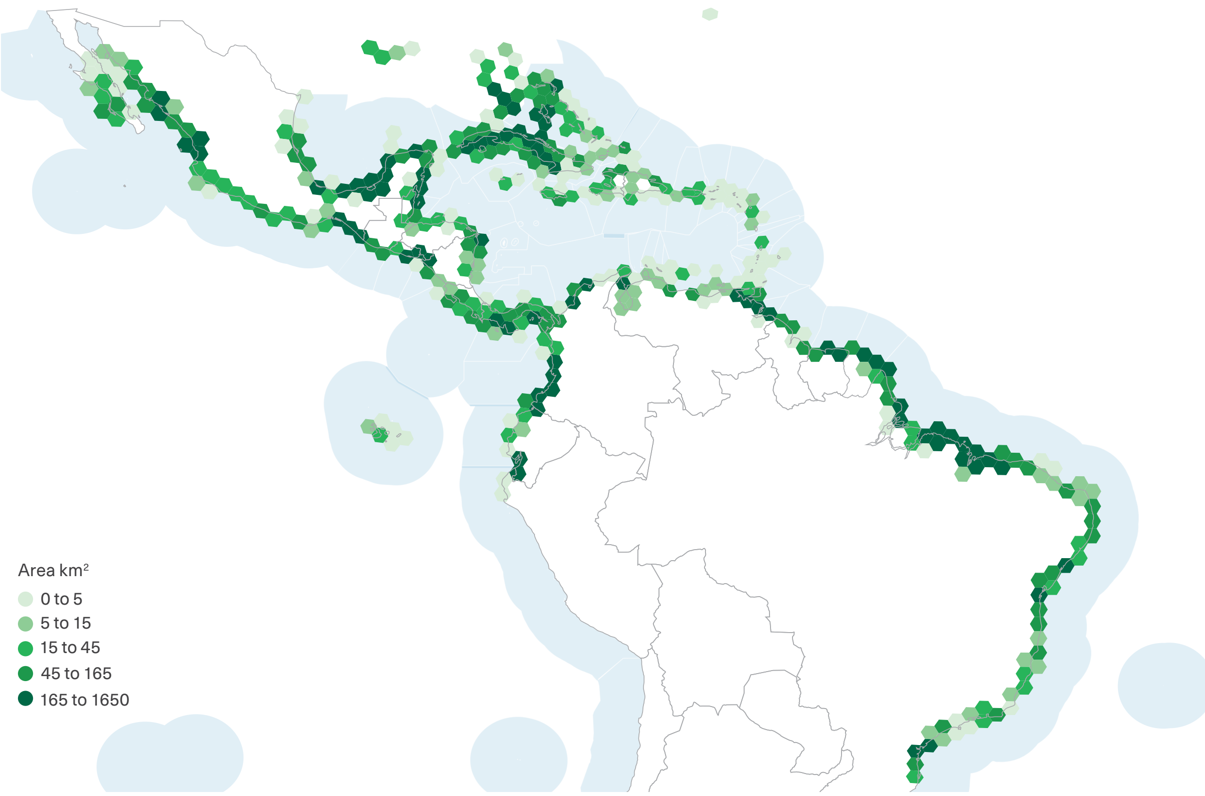
5 The total extent of wetlands is estimated at 930,000 km$^2$ (Reis et al., 2017) as they are also contained within other ecoregions. This is the case of the vegas located in Andean regions and the wetlands in the Gran Chaco region (distributed between Argentina, Bolivia, and Paraguay).

6 Difficulties in adequately measuring carbon sequestration flows, sequestration of organic carbon captured in other upstream ecosystems, and potential methane and nitrous oxide emissions are some of the variables that hinder the ability to adequately measure the mitigation potential of blue carbon strategies (Williamson and Gattuso, 2022).

followed by Cuba (3500 km²), Colombia and Venezuela (2800 km²). However, Cuba, Panama and El Salvador stand out for the high proportion of mangroves in their total area (between 2% and 3%). Mangroves are predominantly composed of a group of tree and shrub species, which are adapted to survive in conditions of salinity, water saturation, and tidal flooding (Hopley, 2010). They have a high carbon potential per unit area, doubling on average the carbon stock contained in tropical forests (Figure 1 in Box 3.4).[7]

Mangroves are a particular type of wetland ecosystem and share the characteristic of being able to capture carbon indefinitely, even once they reach a state of equilibrium with stable biomass per hectare (Leal and Spalding, 2022). They are also a source of methane emissions, which, although relatively low due to their salinity conditions, can offset up to 20% of these ecosystems' annual carbon capture contribution (Rosentreter et al., 2018).

**Graph 3.2**
Distribution of mangroves




**Note:** The graph shows the distribution of mangroves in LAC in 2020. Since mangrove forests are small in relation to the area of the region, they are represented by larger hexagons for better visualization. The color indicates the area of mangroves within each hexagon, measured as km². The colors range from light green, where the mangrove area is less than 5 km², to dark green where it exceeds 165 km². For areas where there are no mangroves, no hexagons are presented.

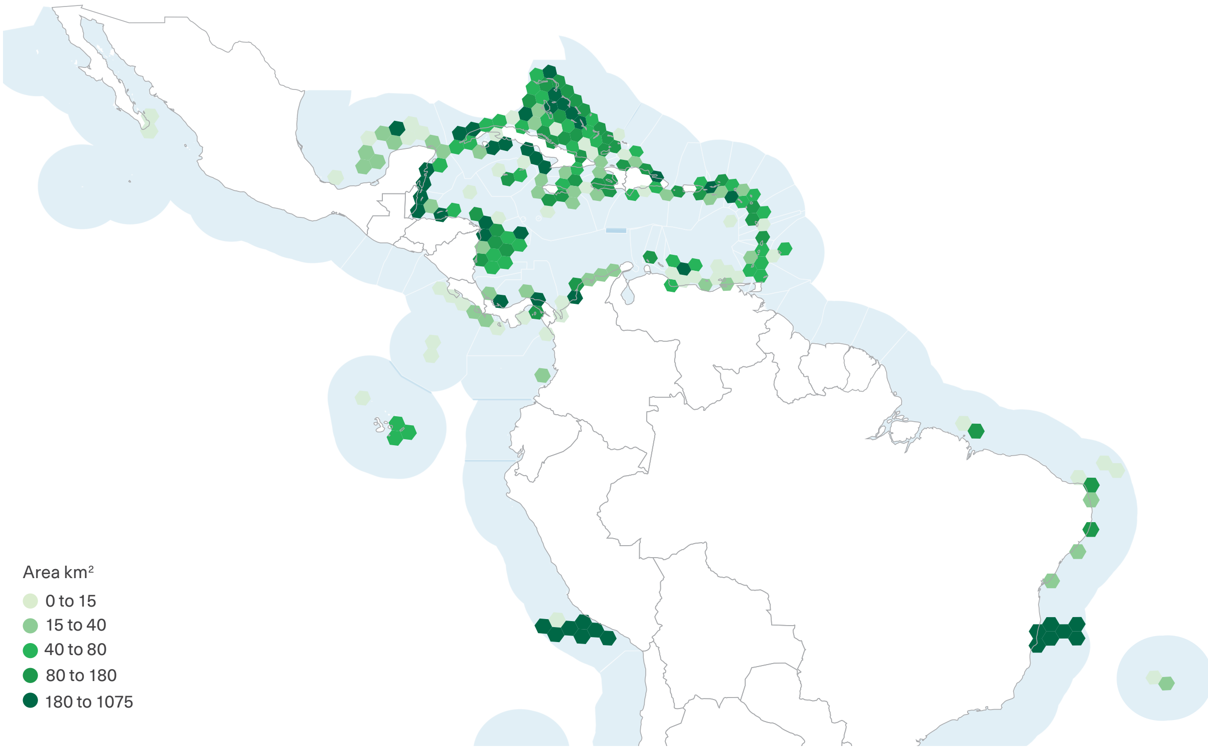
**Source:** Authors based on georeferenced data from Global Mangrove Watch (Bunting et al., 2022) and Flanders Marine Institute (2019) to delineate the exclusive economic zones.

7 Estimates of the carbon stock of mangrove ecosystems vary. Donato et al. (2011) estimate that it is up to four times higher per hectare than that of tropical forests (counting the total carbon stored in biomass above and below the surface and in the soil).

Reefs are submerged ecosystems composed of calcium carbonate structures produced by a group of coral species. Warm-water reefs are found in tropical regions with clear, warm, and shallow waters, mostly up to a maximum depth of 40 meters, as they require significant exposure to sunlight for their survival. On the other hand, cold-water corals are found in deep waters, up to 3,000 meters, and are present in all latitudes. Both warm and cold water corals form structures that slowly accumulate over centuries, providing the habitat on which many species depend. Warm-water corals build up at a faster rate and form barriers that reduce coastal erosion (Hoegh-Guldberg et al., 2017). However, they exist within a narrow range of environmental conditions, particularly temperature, light, and depth, making them highly susceptible to climate change (Kennedy et al., 2013).

**Coral reefs protect coastal populations from extreme weather events, provide habitat for numerous species and are a key tourist attraction for the region**

**Graph 3.3**
Distribution of coral reefs




**Note:** The graph shows the distribution of warm water coral reefs in LAC. Since coral reefs are small relative to the surface area of the region, they are represented by larger hexagons for better visualization. The color indicates the area of mangroves within each hexagon, measured as km². The colors range from light green, where the reef area covers less than 15 km², to dark green, where it exceeds 180 km². For areas where there are no coral reefs, no hexagons are presented.

**Source:** Authors based on georeferenced data from Burke et al. (2011) for coral reefs and Flanders Marine Institute (2019) for delineating exclusive economic zones.

One of the most important services provided by reef and mangrove ecosystems is hosting a prominent biodiversity. They provide habitat for the reproduction and growth of numerous commercially important fish, crustaceans, and mollusks, either caught within the ecosystems themselves or offshore waters. Additionally, the biodiversity and natural beauty of these ecosystems are key tourist attractions for the region.

**Mangroves support commercial fishing for numerous species of fish and shrimp, and provide coastal protection from the increased incidence of storms associated with climate change**

A recent report by the Global Mangrove Alliance analyzes the production value of 37 marketable species. Based on estimates in its analysis, mangroves worldwide support the annual production of nearly 600 billion juveniles, belonging to 32 commercial fish and shrimp species, and more than 100 billion individuals of four species of crabs and one bivalve species. In Latin America and the Caribbean, the number of fish individuals enhanced by mangroves is estimated to exceed 100 million, while habitat restoration in currently degraded or underutilized regions is projected to result in an annual increase of 7.8 million individuals (Worthington and Spalding, 2018).

Mangroves and reefs are also important to prevent coastal erosion, which is key to adapt to climate change in the face of sea-level rise and increased intensity and frequency of storms. Some recent estimates find that, on average, mangroves reduce the wave height caused by wind by 31% and those caused by cyclones by 60% (Narayan et al., 2016). In LAC, mangroves annually reduce flood damages by over USD 12 billion and protect almost 1 million people (Menéndez et al., 2020. Worthington & Spalding, 2018). Coral reefs, on the other hand, can reduce the energy of waves reaching the coast by 97% and their height by 84% (Ferrario et al., 2014; Moomaw et al., 2018).

## Analysis of ecosystem degradation and its causes

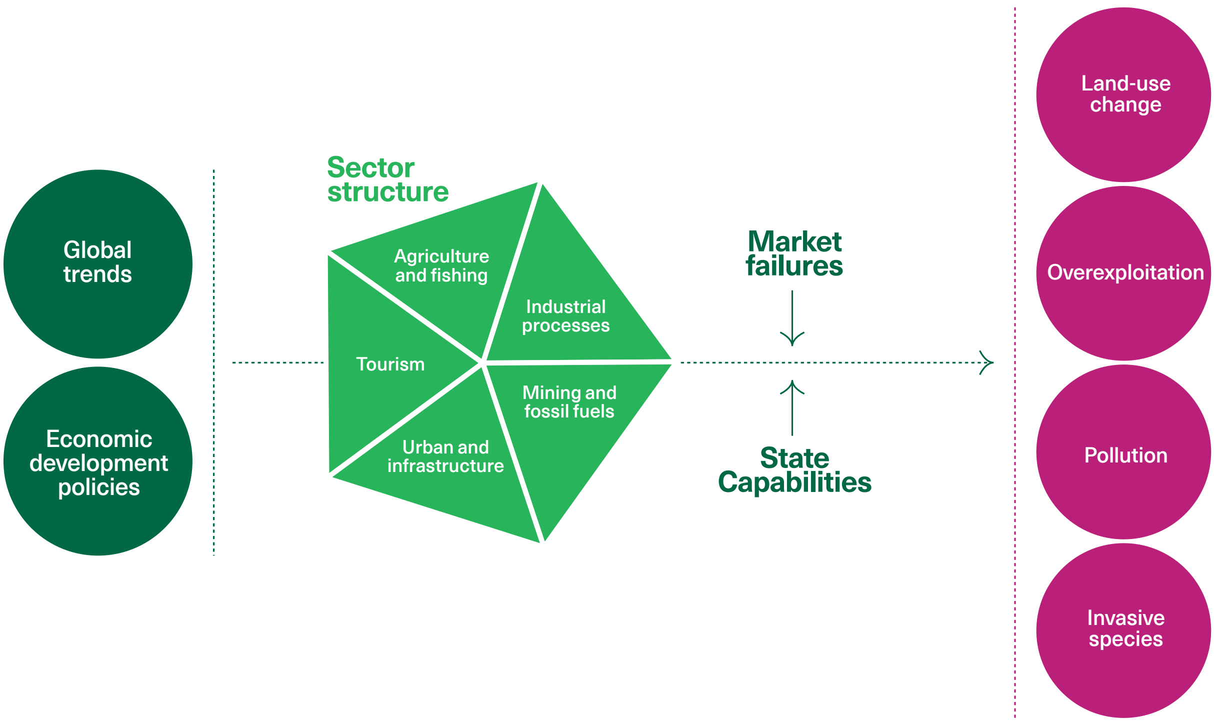
Human activity degrades nature, and the ecosystem services it provides through a combination of direct channels, typically categorized as land-use change, overexploitation of resources, pollution, and the introduction of invasive species . The importance of these channels varies between regions. In the Americas, changes in land use are the primary driver, followed by overexploitation (Díaz & Malhi, 2022).

In addition to these direct channels, human activity also impacts ecosystems through climate change (IPBES, 2019). Chapter 1 introduces the interrelationships between climate change and biodiversity, highlighting how climate change poses a threat to ecosystems through the impact of extreme temperatures, prolonged droughts, and increasing frequency and intensity of storms, among other disturbances.

## Human activity degrades nature through land use change, overexploitation of resources, pollution and the introduction of invasive species

The relative importance of direct degradation channels is associated with the sectoral structure of the region's economies and a set of enabling factors. Global production and consumption trends and countries' responses to them through their economic development policies, determine the relative importance of productive sectors. In turn, these sectors have an impact on ecosystems. The extent of which is determined by the presence of market failures (externalities, public goods, and information problems) and the capacities of States to design and enforce public policies conducive to sustainable development. The interrelationship between direct channels, sectors, and enabling factors is presented schematically in Figure 3.2.

**Figure 3.2**
Direct drivers of ecosystem degradation, productive sectors and enabling factors




**Source:** Authors.

## Land-use change and other drivers of ecosystems degradation

### Change in land use

Land use change, including deforestation, wetland drainage, and the replacement of natural grasslands for food provisioning and production purposes, leads to the loss and fragmentation of habitats for numerous species and ecological processes. It also results in the loss of ecosystem services and an increase in greenhouse gas (GHG) emissions.

To quantify the extent of land use change in the region, data from Gauthier et al. (2021) is utilized, which classifies soils into categories such as natural, semi-natural, rangelands, croplands, and settlements. The "natural" category refers to regions without significant human presence or impacts, while "semi-natural" refers to areas with low human presence and low-intensity use. The remaining categories are considered anthropogenic due to continuous and high-intensity human uses.[8]

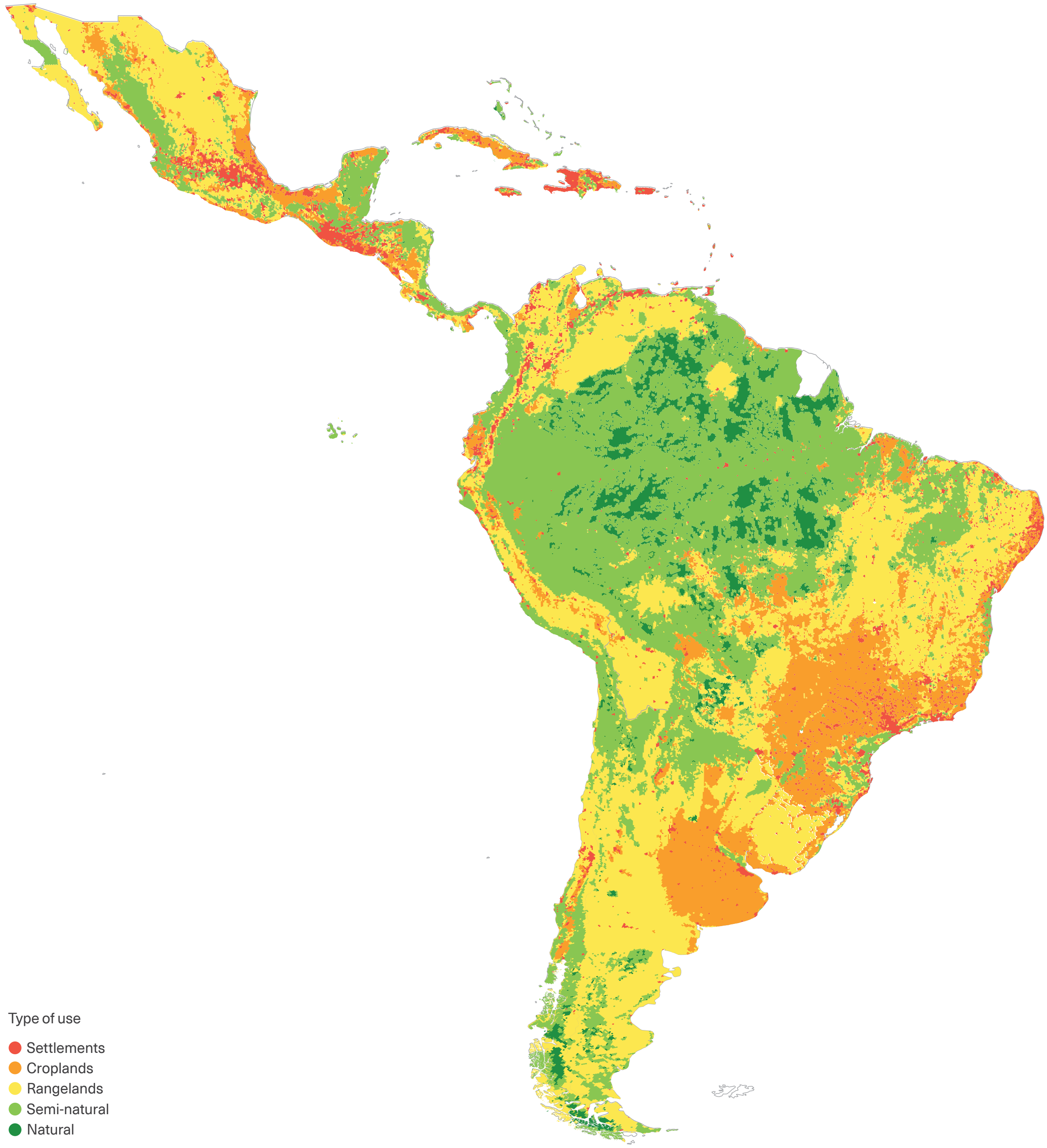
Graph 3.4 displays the land use types across the entire region in 2017 (Gauthier et al., 2021). The majority of the region's surface area (55%) is predominantly under anthropogenic use, indicating intensive human activities. Approximately 6% is conserved in a natural state, and 39% is categorized as semi-natural. However, as reported in panel E of the same graph, the conservation of ecosystems in a natural or semi-natural state varies significantly among regions. In South America, it reaches 56%, while in Mesoamerica and the Caribbean, it is 27% and 19%, respectively.

**In South America, ecosystems in a natural or semi-natural state cover 56%, while in Mesoamerica and the Caribbean it is 27% and 19%, respectively**

8 For more details on soil classification, see Gauthier et al. (2021). Clarifications regarding Graph 3.4 can be consulted in the online appendix.

**Graph 3.4**
Anthropic land use in 2017 by type of ecoregion

**Panel A.**
**Total**

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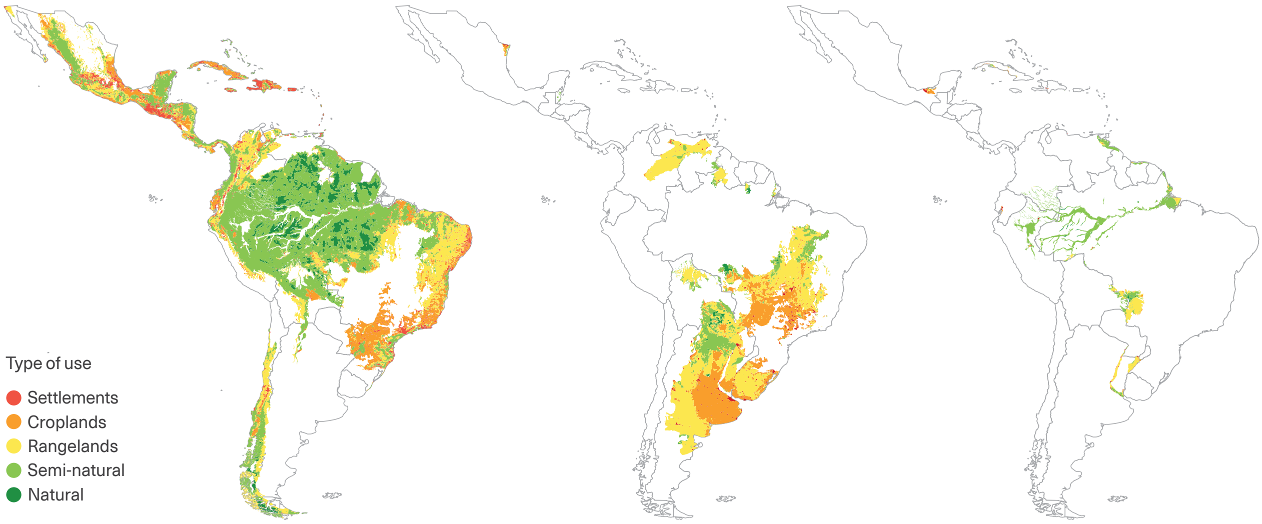
**Panel B.**
**Forests**

**Panel C.**
**Grasslands, savannas, and shrublands**

**Panel D.**
**Wetlands**




**Panel E.**
**Distribution by region and predominant natural cover**

| | | Caribbean | Mesoamerica | South America | Total |
|---|---|---|---|---|---|
| Total | Settlements | 38.0 | 11.5 | 3.0 | 4.4 |
| | Croplands | 34.7 | 18.7 | 15.7 | 16.3 |
| | Rangelands | 8.5 | 43.1 | 33.8 | 34.6 |
| | Semi-natural | 18.2 | 26.7 | 41.0 | 39.0 |
| | Natural | 0.6 | 0.1 | 6.6 | 5.7 |
| Forests | Settlements | 40.5 | 14.5 | 3.6 | 5.7 |
| | Croplands | 36.9 | 22.6 | 11.8 | 13.7 |
| | Rangelands | 7.0 | 24.9 | 19.8 | 20.3 |
| | Semi-natural | 15.6 | 37.9 | 54.6 | 51.7 |
| | Natural | 0.1 | 0.1 | 10.2 | 8.7 |
| Grasslands | Settlements | - | 10.2 | 2.2 | 2.2 |
| | Croplands | - | 47.6 | 30.3 | 30.4 |
| | Rangelands | - | 15.6 | 52.1 | 52.0 |
| | Semi-natural | - | 26.6 | 14.0 | 14.0 |
| | Natural | - | 0.0 | 1.4 | 1.4 |
| Wetlands | Settlements | 10.6 | 20.6 | 1.4 | 1.9 |
| | Croplands | 29.5 | 66.7 | 2.3 | 4.0 |
| | Rangelands | 28.9 | 8.4 | 23.9 | 23.6 |
| | Semi-natural | 30.9 | 4.3 | 69.7 | 67.9 |
| | Natural | 0.0 | 0.0 | 2.7 | 2.6 |

**Note:** The graph shows land use by humans in 2017. Panel A displays this indicator for the entire region, while panels B, C, and D do so for forest, grassland, and wetland covers, respectively. Panel E presents the land use values for each of these covers (rows) and each of the subregions of LAC (columns). The values are expressed as a percentage and represent the share of each type of human land use in each combination of cover-subregion (e.g., the data in row 7, column 1 tells us that 36.9% of the Caribbean's territory that belongs to a forest ecosystem was used for cultivation in 2017). The ecoregions considered within forests, grasslands, and wetlands, as well as the countries in each subregion of LAC, can be found in the appendix of this chapter, available online.

**Source:** Authors based on data from Gauthier et al. (2021) and Ecoregions2017 (Dinerstein et al., 2017).

## Box 3.5
Determinants of land use change

The main alternative land uses that drive the loss of natural cover can be categorized as follows: 1) food production for human consumption, 2) food production for energy generation, 3) fiber and timber production, and 4) land occupation for infrastructure and cities. In this categorization, the emphasis is placed on the purpose of human consumption associated with each land parcel rather than the specific activity carried out on it. For example, energy production has its own category, despite being based on agricultural products that could be used for food (e.g., soybean and oil palm biodiesel).

Population growth and per capita consumption increase the pressure on land use, while productivity, which reduces the area required to generate a unit of production, decreases it. In turn, the change in the composition of the average diet, in favor of a higher proportion of animal calories as income level increases, results in an increase in land demand (Cole and McCoskey, 2013) due to the loss of efficiency in the conversion of plant calories (or protein) to animal calories. Animal species is also of great relevance, as feed conversion varies widely and, in general, decreases with size, with feed conversion ratios for cattle being more than four times lower than those for poultry.

In a study on the drivers of agricultural land use change, Alexander et al. (2015) found that between 1961 and 2011, global land use increased by 625 million hectares, which represents nearly one-third of the total land area of South America. This increase is attributed to human food consumption (535 million ha), bioenergy (35 million ha), and waste (25 million ha). In terms of food consumption, the growth in land use driven by changes in the average diet composition is equivalent to a population growth rate 50% higher than the observed rate. In contrast, the significant increase in agricultural yields achieved through productivity improvements and input intensification offset 90% of the increase in land demand for food production.

The data reveal that habitat loss and fragmentation in Latin America and the Caribbean is strongly linked to the agricultural sector: 35% of the region's surface area is destined to grazing and 16% to crops. Human settlements occupy 4% of the territory. While the agricultural sector remains important, the Caribbean exhibits a different land use pattern compared to the regional average. In this subregion, the area dedicated to grazing is considerably lower (8%), while the proportion of land used for crops (35%) and human settlements is higher (38%).

**Habitat loss and fragmentation in Latin America and the Caribbean is strongly linked to the agricultural sector: 35% of its area is used for grazing and 16% for crops**

The agriculture and forestry sector serves numerous and growing societal demands: food, timber for construction, paper pulp, clothing fibers (wool and cotton), energy in the form of charcoal and biofuels (see Box 3.5).

The specific land use and the type of modified ecosystem determine the level of degradation and emissions generated (Felipe-Lucía et al., 2020; Kleijn et al., 2009). For example, livestock production that relies on grazing can be considered a less intensive land use compared to seasonal crops, as it is compatible with greater diversity of plant and animal species in the area. However, pastoral use does require drastic modification of the ecosystem when carried out in forests, as it requires deforestation and the introduction of foreign grassland species.

Panels B, C, and D of Graph 3.4 show land uses in the ecoregions dominated by forests, grasslands, savannas and shrublands, and wetlands. As explained in the previous section, these land covers are of great importance for global carbon capture and storage, both in terms of carbon density and extension. Together, the ecoregions grouped under these three land covers represent 86% of the land area in Latin America and the Caribbean. While all of these land covers show significant land use change, the impact is higher in grasslands, savannas, and shrublands. In those areas, productive uses account for 85%, compared to 40% and 30% in forests and wetlands, respectively.

Thirty-nine percent of the area of forest ecoregions in Latin America and the Caribbean has a predominantly anthropogenic land use (20% for grazing, 14% for crops, and 6% for settlements), while 52% is in a semi-natural state and 9% in a natural state. The relatively preserved state is mainly due to the Amazon biome, although even this shows clear losses in the southern and southeastern border (see Box 3.6). The temperate forests in southern Patagonia, which are smaller in extension, still have a significant portion of their area in a natural or semi-natural state, as do significant areas in eastern Mexico, eastern Honduras, Costa Rica, and Panama. Although these latter areas have smaller surface areas, they are significant for wildlife migration and bird corridors between South America and Mesoamerica. In contrast, the forests in eastern South America, the remaining forests in Mesoamerica, and those in the Caribbean show predominantly anthropogenic land use, reaching 84% in the latter subregion.

**In the last 20 years, forests in Latin America and the Caribbean experi enced net losses of 5% (47 million ha), equivalent to 1.2 times the area of Paraguay**

The main reason behind forest loss in Latin America and the Caribbean is deforestation for agriculture and livestock activities, which covers 34% of the total land area. Within this activity, it is notable that in South America and Mesoamerica, pastoral land use represents one-fifth and one-fourth of the total forest biome area, respectively. Large areas of land in forest ecoregions are being converted for human use, particularly in Colombia, creating a corridor in the western region of the Andes toward southern Peru. This is also the case in the southern border of the Brazilian Amazon and virtually throughout the Atlantic Forest ecoregions, which encompass tropical and subtropical, moist, and dry forest biomes. In the Caribbean, almost the entire forest biome area is now under human use, with similar proportions of agricultural and livestock use (44%) and human settlements (41%).

## Box 3.6
Deforestation in the Amazon[a]

In the 1970s, a process of profound transformations began in the Amazon due to large-scale deforestation, disrupting an ecosystem that had been preserved for millennia. Today, the Amazon has 15% less forest area than in the past. Brazil has the highest degree of deforestation compared to the original surface area of the Amazon (21% of the region). It is followed by Bolivia, Colombia, Ecuador, and Peru, with a loss of around 10%. Meanwhile, Guyana, French Guiana, Suriname, and Venezuela have lost less than 4% of their original Amazonian territory.

Deforestation of the Amazon is concerning both for the immediate loss of forests and biodiversity and the possibility of reaching a tipping point where the ecological balance mechanisms themselves generate a process of desertification in the area, which could be irreversible (see Box 1.2). Lovejoy and Nobre (2019) estimate that this tipping point could be triggered with the loss of between 20% and 25% of its forested area.

The expansion of agricultural and livestock frontiers is the main direct cause of Amazon deforestation. In Brazil and Bolivia, this process initially involved the introduction of soybean cultivation, followed by the conversion of forests into pasturelands for livestock. Cattle ranching is also responsible for deforestation in Colombia and Peru. With less impact, the expansion of coca plantations has driven deforestation in Bolivia, Colombia, and Peru, while palm oil production has had the same effect in Ecuador and Peru.

Logging and mining are other causes of deforestation, albeit on a smaller scale. The timber industry focuses on the extraction of "Mahogany" and "Ipe" since the rest of the tree species have little commercial value. Mining, on the other hand, primarily targets gold extraction, mainly in Guyana, French Guiana, Suriname, and Venezuela.

### Table 1
Amazon deforestation by country

| Country | Amazon forest area | Area (thousands of km²) | Proportion preserved as primary forest | Area lost (thousands of km²) | Main reasons for deforestation |
|---|---|---|---|---|---|
| All countries | 100% | 6,387 | 85% | 960 | Cattle ranching, timber, coca, palm oil, mining |
| Bolivia | 6.9% | 442 | 92% | 35 | Livestock, soybean |
| Brazil | 60.3% | 3,859 | 79% | 810 | Livestock, soybean |
| Colombia | 6.9% | 442 | 88% | 53 | Livestock, coca |
| Ecuador | 1.5% | 96 | 90% | 10 | Palm oil |
| French Guyana | 1.1% | 70 | 97% | 2 | Gold mining |
| Guyana | 3.0% | 192 | 99% | 2 | Timber, gold mining |
| Peru | 11.3% | 723 | 92% | 58 | Coca, palm oil, cocoa |
| Suriname | 2.1% | 134 | 96% | 5 | Gold mining |
| Venezuela | 6.7% | 429 | 96% | 17 | Gold mining |

**Source:** Ferreira (2023).

Logging in the Amazon is highly regulated in most countries, so most deforestation that occurs today is illegal. For example, it is estimated that in Brazil only about 3% to 4% of annual deforestation is legal (Valdiones et al., 2021). Deforestation is mainly carried out by small and medium-scale farmers and miners, who often have connections with large legal and illegal networks for the sale and trade of the obtained goods. One example is cattle ranchers in Brazil who sell their products to formal companies that later market the cattle as their own (Abreu, 2022). Another example is coca producers collaborating with drug trafficking organizations in Colombia and Peru.

In addition to the loss of biodiversity and ecosystem services, deforestation in the Amazon leads to negative externalities such as air pollution (due to the use of fires to clear vegetation) and water contamination (due to the use of mercury in mining activities). The underlying problem is that, despite being an illegal activity with high social costs, deforestation remains profitable for those involved in the economic exploitation of the Amazon.

[a] This box is based on the document “Amazon deforestation: drivers, damages, and policies,” written by Alipio Ferreira (2023) as part of the inputs commissioned for this report.

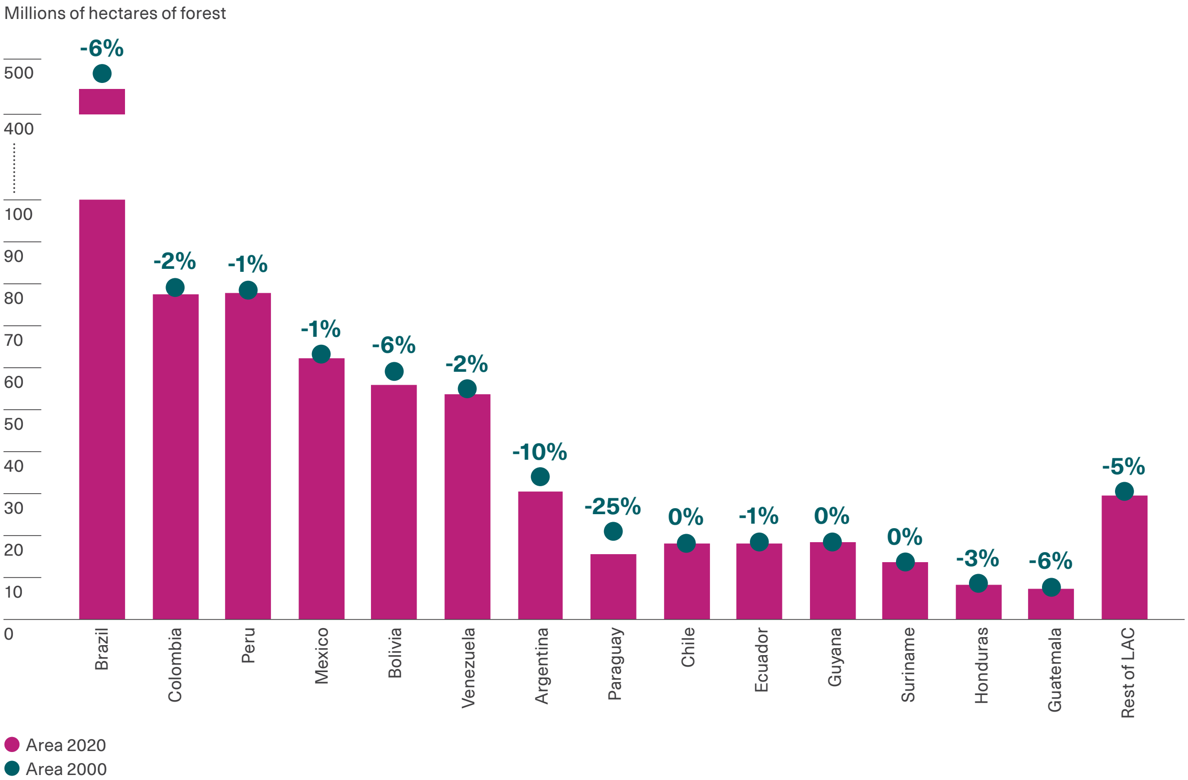
The expansion of anthropogenic land use in forests continues at an accelerated pace in LAC, as evidenced by observed deforestation rates. At the beginning of the century, the region had a total forest area of 979 million hectares, roughly equivalent to the combined land area of Bolivia and Brazil.[9] However, over the course of 20 years, it experienced net losses of 5% (47 million hectares), equivalent to 1.2 times the area of Paraguay. These losses varied greatly among countries. Paraguay has by far the highest loss rate, reaching 25% of its remaining forest area in the year 2000, followed by Argentina at 10%. However, Brazil is the largest contributor in absolute terms to deforestation in the region, with three out of every five hectares of forest lost during that period (see Graph 3.5). The recorded gross losses are even higher, reaching 6.5%, or 63 million hectares, a value greater than the net losses, which consider tree plantations and forest regrowth in unused agricultural areas. While these areas help slow down the net loss of forest cover, they have lower biodiversity value compared to the primary forests that have been lost.

The grassland, savanna, and shrubland ecoregions of Latin America and the Caribbean are the most affected by human activities. In 2017, only 15% of these regions remained in a natural or semi-natural state (see Graph 3.4). Over half of the total area is used for grazing, while cultivated areas account for approximately one-third of the total.

The loss of natural grassland cover has markedly slowed since 2000, with an annual loss rate of 3,000 $km^2$ between that year and 2017, compared to the 15,000 $km^2$ annual loss rate recorded between 1980 and 2000. However, there has been a significant intensification of land use in recent years, as the proportion of annual crops has increased at the expense of grazing land. The share of annual crops in the total anthropogenic land use has risen from 29% to 36% (see Graph A.3.1 in the appendix of the chapter, available online).

9 The estimates of Potapov et al. (2022) are based on the analysis of satellite images with a 30 meters by 30 meters resolution. These results were calculated on the basis of defining forests as those grids with a tree cover greater than 30% and with trees of a height greater than or equal to 5 meters.

**Graph 3.5**
Deforestation in Latin America and the Caribbean between 2000 and 2020




**Note:** The graph shows the amount (in millions of hectares) of forest for each country in 2000 (the circles), 2020 (the bars) and the percentage change between both periods. The countries included in the "rest of LAC" category correspond to the 33 countries that make up CELAC, except for those that are represented individually.

**Source:** Authors based on data from Potapov et al. (2022).

Regarding wetland ecoregions, the percentage affected by anthropogenic uses is relatively low, accounting for less than 30% of the total. However, there is considerable heterogeneity among regions, ranging from areas with minimal impact in the Amazon basin to regions almost entirely affected in the Paraná Delta. In fact, once wetlands in the Amazon biome are excluded, the percentage of anthropogenically used land in wetland-dominated ecoregions reaches 65%. In Mesoamerica, less than 5% of the total area remains unaffected by anthropogenic uses.

Grazing dominates the land use in wetland ecoregions, representing 80% of the total anthropogenic use. Between 2000 and 2017, the anthropogenic use of wetlands increased by approximately 8%. Additionally, there is continued intensification of land use, as the area used for crops has grown by nearly 40% during that period (see Graph A.3.2 in the appendix).

Beyond the direct impact of land-use change on wetlands, these ecosystems can be affected by distant human activities that modify the water flows upon which wetland systems depend. For example, the placement of urban infrastructure upstream from a delta can have an impact on wetlands by disrupting natural hydrological cycles and sediment inputs. Hence, assessing the extent of ecosystem deterioration caused by these distant activities can be challenging, and relying solely on local factors is insufficient (Pittock et al., 2015; Reis et al., 2017).

Urban use and the placement of transportation infrastructure represents a very small fraction of the surface area used in the region (4.4%), although it occupies 38% of the surface area of Caribbean countries. It stands out for being the most profound transformation of the ecosystems in which it is located. I n addition, its expansion can have profound impacts on highly valuable ecosystems because natural beauty is a feature highly valued by the market, but subject to significant externalities. Radeloff et al. (2010) provide an example of this phenomenon by documenting that the growth rate of housing in the vicinity of protected areas in the United States exceeds the national average by 50%, which significantly compromises the ability to safeguard the biodiversity of these areas. The incentives for urban expansion along the coastline are another example. They have major implications for key ecological processes of coastal ecosystems, such as wildlife passage and the hydrology that supports carbon sequestration in marshes and mangroves (Dafforn et al., 2015; Heery et al., 2018).

It is important to highlight the role of the management model of each activity in producing environmental outcomes. Specific practices can significantly mitigate the impacts that activities have on the environment. In urban areas, the protection of biodiversity within cities is becoming an integral policy objective. This shift is driven by a deeper appreciation of nature's contributions to the well-being of urban residents. Additionally, efforts to mitigate the environmental impact of cities on the natural environment are also gaining prominence within policies. This reflects a growing understanding of the need to preserve the environment even within urban settings (see Box 3.7 in the final section of this chapter).

Furthermore, diversified agricultural production, particularly agroforestry systems with crop rotation, has less impact on biodiversity because it allows for the establishment of bird and insect communities in forest patches (see Chapter 2). The greater diversity and abundance of birds and insects provide enhanced pollination services that benefit crops. Additionally, crop diversity and rotation result in lower pest incidence through the establishment of food chains. However, this production model can come into conflict with biodiversity conservation when economies of scale that impact agricultural yields are not fully utilized, resulting in the need for larger land areas to maintain the same level of production.

●●

**Urbanization and transportation infrastructure generate the most drastic changes in ecosystems**

In addition to the large percentage of land affected by human uses, the areas in Latin America and the Caribbean that still have a low level of disturbance are increasingly fragmented and disconnected. At times, the degree of fragmentation can reach critically high levels, jeopardizing the survival of plant and animal communities. This occurs primarily because the surface area of the remaining habitat patches is insufficient to sustain populations large enough to ensure the genetic variability required for long-term survival. Additionally, the lack of connectivity between natural regions hinders species movement across latitudinal and altitudinal gradients, which is considered crucial in the face of rising global temperatures. While estimating these critical levels is challenging, this phenomenon is recognized as a central mechanism in biodiversity loss and is known as the extinction debt (Halley et al., 2014; Ridding et al., 2021; Tilman et al., 1994; Wearn et al., 2012).

### Overexploitation

The overexploitation of natural resources refers to the extraction or use of renewable natural resources beyond the sustainable rate, which is the rate that allows for sustained extraction over time. This is another significant cause of ecosystem degradation and biodiversity loss in the region.

Overexploitation is a characteristic phenomenon in the fishing industry due to the diffuse property rights over water bodies. In the case of inland waters, lakes and rivers often serve as boundary lines between countries or administrative divisions within them, making governance over shared resources challenging. In the case of the oceans, most of the surface area corresponds to international waters where all countries enjoy equal rights of access and use. These difficulties are further compounded by the fact that fish resources move across territories subject to different regulations, state capacities, and levels of exploitation.

Overfishing has major consequences for aquatic ecosystems that go beyond the reduction in commercially valuable fish stocks. By depleting the stock of exploited species, it disrupts the balance of the food chain and enables invasive species to develop. Moreover, non-commercial species affected by incidental fishing may face even greater threats to their survival. A notable case in Mesoamerica is the fishing of the totoaba fish in the Gulf of California, which has virtually led to the extinction of the vaquita porpoise, a cetacean species similar in size and distribution to the fish. In the Caribbean, the overfishing and degradation of coral reef is pushing many fish species, including commercially valuable ones such as tuna and groupers, towards extinction (Linardi et al.,2017). In South America, the world's largest fishery by volume—the anchoveta—experienced collapses in 1973, 1983, and 1988.

**Overexploitation is a characteristic phenomenon in the fishing industry due to diffuse property rights over water bodies**

Other sectors strongly associated with overexploitation are tourism and the extraction of non-timber forest resources. In the island countries of the Caribbean, for example, tourism is a key sector for the economy, largely driven by the natural beauty of their beaches, where the biodiversity present in mangroves and coral reefs is a central attraction. However, the massive influx of visitors is another way of overexploitation that threatens these delicate ecosystems. Erosion and physical damage caused by mass tourism, pollution from motorized vessels, and habitat destruction due to coastal development are some of the mechanisms that affect these ecosystems and compromise the services they provide (IPBES, 2019).

Finally, in the agricultural sector, intensive and inadequate soil management exacerbates the overexploitation of water resources. This can also be considered a case of overexploitation as it results in nutrient loss and degradation of soil properties (compaction, low permeability, etc.), a phenomenon known as "soil mining."

### Pollution

Air, water, and soil pollution is the result of waste generated during the extraction of natural resources, and the production and consumption of goods and services. It is a negative externality that affects human wellbeing not only through the degradation of ecosystems and the services they provide but also through its direct impact on human health .

The most common air pollutants are fine particulate matter, tropospheric ozone, carbon monoxide, sulfur oxides, and nitrogen oxides (WHO, 2021), which are harmful to biodiversity and human health. Water, on the other hand, is affected by waste containing high concentrations of nutrients (such as nitrogen and phosphorus), pathogenic microorganisms, plastic waste, persistent organic pollutants, and heavy metals. Nutrient enrichment in aquatic ecosystems promotes the growth of algae and microorganisms, reducing oxygen content in the water, a phenomenon known as eutrophication. This can have severe impacts on fish and invertebrate communities, including the formation of "dead zones" observed in marine ecosystems since the 1960s (Diaz and Rosenberg, 2008).

## Air, water, and soil pollution is the result of waste generated during the extraction of natural resources and the production and consumption of goods and services

The presence of persistent organic pollutants and heavy metals in water and air, even in very small concentrations, can have major impacts on biodiversity and human health as they accumulate in tissues throughout life, a process known as bioaccumulation. Moreover, the concentration of organic pollutants and heavy metals increases as it moves up from one trophic level to another, a phenomenon called biomagnification. This leads to increased morbidity and mortality in these species and harmful effects on human health when consumed as food (Stockholm Convention Secretariat, 2017). Mercury stands out for its high biomagnification potential (Córdoba-Tovar et al., 2022) and its drastic consequences for human health, including impacts on neurological development (AMAP and UNEP, 2019). Anthropogenic emissions of mercury, a heavy metal, have resulted in a 450% increase in estimated environmental concentrations, exposing communities in the Amazon and the Caribbean that heavily rely on fish for their sustenance (AMAP and UNEP, 2019).

The hydrocarbon extraction and mining sectors, in addition to their significant contribution to global warming through high energy consumption (see Chapter 2), are closely associated with local air and water pollution. Hydrocarbon extraction also produces significant GHG emissions due to methane, which is sometimes released directly into the atmosphere or burned on-site when its storage or transportation to consumption sites is not profitable. Even in cases where this gas is used, it is almost inevitable that significant leakage occurs, making it challenging to measure. On the other hand, surface mining affects air quality primarily through the release of fine particles and contaminates the water bodies through the introduction of heavy metals. Mercury is a key input in artisanal gold mining that contaminates both water and air and is responsible for 38% of global emissions (AMAP and UNEP, 2019). The burning of coal, other fossil fuels, and biomass to meet the energy needs of households and industries, among other purposes, accounts for a quarter of global mercury emissions (AMAP and UNEP, 2019).

The agricultural sector is a significant source of diffuse pollution on water bodies. Among the main pollutants are excessive sediment, nutrients (potassium and phosphorus), and dissolved organic carbon. With a growing importance in regional production processes, herbicides have harmful impacts on the health of downstream populations (Dias et al., 2023).

Cities affect the ecosystems they are embedded in through GHG emissions and local air and water pollutants. The transportation sector is responsible for substantial carbon emissions and local pollutants, particularly when it relies on private vehicles (see Chapter 2). In cities, inadequate and insufficient processing of sewage is usual, which often harms the water bodies where it is discharged. The excessive nutrient input from these effluents leads to eutrophication. Additionally, chemicals from cleaning products decrease the resilience of water bodies, altering the communities of microorganisms that inhabit them. Runoff and infiltration of precipitation in cities carry pollutants derived from petroleum and cleaning chemicals dumped in urban soils.

Pollution presents a significant challenge for public policy due to its intricate nature and the multitude of agents involved, both in terms of pollution sources and in the broad range of individuals and ecosystems affected by it. For example, when attempting to reverse the eutrophication of a watercourse caused by nutrient runoff from the agricultural sector, it is necessary to identify all relevant producers in the watershed and the type of production they engage in, as well as monitor the specific practices they carry out. Although it is highly relevant to human wellbeing and ecosystem health, discussing the best policies to tackle pollution is beyond the scope of this chapter.

### Invasive species

The introduction of invasive species, pests, and diseases disrupts the balance of an ecosystem and can severely harm prevailing biodiversity. Its impact on climate change is less significant than the previously mentioned channels and therefore falls outside the scope of this chapter. However, it is important to recognize that it is a phenomenon that increasingly needs to be addressed by public policies.

Pastoral land use often involves the introduction of foreign grassland species that are more productive under local climatic conditions. In general, these species can spread beyond the production-affected regions, competing with native plant species and altering natural fire cycles. Cities and towns play a significant role in the introduction of foreign species through the use of ornamental plants and the keeping of wild species as pets. They also encourage the proliferation of species that adapt to urban environments (McKinney, 2006). The adoption of wild species as pets often results in accidental or deliberate introductions of alien species into the wild, which can cause major ecological imbalances (Gippet and Bertelsmeier, 2021; Lockwood et al., 2019). In the case of ornamental plants, it is difficult to prevent their dispersal into natural areas with unknown long-term consequences.

Climate change and environmental modifications can significantly affect the spread and establishment of invasive species by modifying the territorial range they can inhabit. For example, rising water temperatures and nutrient enrichment contribute to decreased oxygen levels, allowing more resilient species to dominate in the ecosystem. A notable example is the snakehead fish, native to Asia, which has invaded aquatic habitats in North America, partly due to its ability to breathe air.

Maritime transport of goods is an important vector for the dispersal of species with invasive potential between connected regions . Ships often carry large volumes of ballast water containing eggs and plankton. Their role in the introduction of invasive species is growing as travel times between origins and destinations decrease, favoring a higher survival rate for these organisms (Costello et al., 2010). An example is the veined rapa whelk, a saltwater snail native to Asia that has developed on the coasts of South America, possibly through maritime trade. This species has significantly affected important ecosystem services in the delta of the Río de la Plata, reducing populations of commercially valuable bivalves that contribute to water filtration and purification (IPBES, 2019).

**Maritime transport of goods is an important vector for the dispersal of species with invasive potential between connected regions**

## Enabling factors

Rapid economic and population growth is the most prominent trend since the industrial revolution, directly impacting society's demands on nature. A larger population leads to higher aggregate consumption. In addition, rising per capita income deepens demand. For example, the share of animal-based products within total food expenditures increases as income rises (Haushofer and Shapiro, 2016; Jayachandran, 2022; Worku et al., 2017). This exerts pressure on land-use change because animal products are more land-use intensive per unit of output. Moreover, income growth drives demand for goods and services with high environmental footprint (e.g., housing, air travel, short life-cycle clothing, etc.).

Technological development can have both beneficial and detrimental effects on the ecosystems. On the one hand, it increases productivity and reduces inputs required per unit of production (as discussed in Box 3.5) while offering techniques with a lower environmental impact. On the other, technology enables new ways to extract commercial value from natural resources, sometimes facilitating harmful practices to the ecosystems. Genetically modified crops, for example, increase agricultural yields and promote no-till farming, improving sustainable soil management (see Chapter 2). However, they also enable expanding the agricultural frontier into previously unviable or unprofitable areas, affecting climate change and biodiversity through land-use change. Furthermore, they are associated with the widespread use of non-selective herbicides, which can contaminate watercourses and harm human health (Dias et al., 2023). Another example is the intricate relationship between technological advancements and ecosystem degradation, as seen in the case of biofuels. Advances that reduce the costs of producing traditional biofuels (e.g., ethanol and biodiesel) facilitate the substitution of fossil sources with higher carbon emissions and other local air pollutants. However, their production already has a significant and increasing share of global land use and pressures ecosystems through land-use change.[10]

The set of economic development policies chosen by countries is also a determinant of impacts on ecosystems. Based on global trends and the opportunities presented by each country's endowments, societies and states seek to address multiple and diverse objectives to meet their needs at a given time. In most countries in Latin America and the Caribbean, development strategies in the past century focused on harnessing their natural resources, turning the region into an exporter of food, hydrocarbons, and tourism services (see Chapter 2). However, the policies pursued often prioritized the short-term societal needs such as poverty alleviation and economic growth at the expense of the sustainability of growth itself and the preservation of ecosystems.

**The development policies of Latin America and the Caribbean focused on harnessing their natural resources, prioritizing short-term economic needs, at the expense of the sustainability of economic activity and the preservation of ecosystems**

Three aspects with negative effects on ecosystems stand out in these policies. First, the widespread use of direct and indirect subsidies in the agricultural, fishing, and energy sectors, affects ecosystems by distorting economic incentives for consumers and companies. While these subsidies may pursue valuable objectives, such as reaching food sovereignty, reducing consumer prices, and promoting exports, they can also have detrimental effects on ecosystems. This occurs when subsidies increase the returns producers receive out of land-use change, overexploitation of natural resources, and unsustainable practices. The following section discusses subsidy reform as an area within market-based policies for ecosystem protection.) Second, investments in expanding transportation infrastructure in areas with limited prior human presence have favored ecosystem degradation by facilitating access to new territories. The expansion of roads and railways leads to the relocation of individuals and productive activities, typically resulting in increased production and degradation of the affected ecosystems (Asher et al., 2020; Jayachandran, 2022). Lastly, some countries have been made provisions to change land use for productive purposes on public lands through laws or amnesties that allow private land titling in areas where private investments have been made.

The set of economic development policies that are established in response to global trends and the endowments (or comparative advantages) of the countries determine their sectoral composition. As Chapter 2 shows, Latin America and the Caribbean

10 A widely debated hypothesis in this regard is that the relationship between development and environmental impact follows an inverted U-shaped pattern, where economic development beyond a certain level is accompanied by a lower environmental impact, known as the Environmental Kuznets Curve (Grossman and Krueger, 1991). The hypothesis is based on the premise that the demand for environmental quality increases with income levels and that a higher income enables investments in lower-impact technologies. However, the current consensus on this hypothesis suggests that the evidence from the past few decades indicates a monotonic relationship between development and environmental impact (Stern, 2017).

has a sectoral structure and trade integration dominated by agricultural production, with some economies, such as Venezuela, Brazil, and Trinidad and Tobago, traditionally intensive in fossil fuel exports and those of most of the Caribbean Island States based on tourism. The sectoral structure of each economy is connected with the direct channels of ecosystem degradation. In turn, the impact of a country's economic structure on ecosystems, is determined by the prevalence of market failures and the capacities that States have to address them.

To analyze these market failures, it is useful to consider separately the areas of private property and those of public property. First, the natural resources found in privately owned areas generate a flow of ecosystem services with varied geographical reach. A portion of this flow is received by the property owners who benefit from the land, while another portion constitutes a positive externality, as the beneficiaries typically do not contribute to the costs of conservation. Therefore, when making management decisions, land occupants only consider the private costs and benefits resulting from managing their property, often choosing a suboptimal level of conservation for society.

On the other hand, information problems can also cause excessive degradation of ecosystems on privately owned sites. This may occur when the full extent of impacts caused by human activities on ecosystems is not known with certainty. While research and development efforts contribute to increasing the global knowledge base, closing the knowledge gap that affects individuals and companies requires significant and ongoing efforts. Additionally, both actors are often subject to shocks and financial constraints that lead them to favor short-term returns over the long-term sustainability of their activities. This is especially important in low-income contexts with limited access to credit.

Ecosystems on public property—such as state lands, aquifers, and water bodies—face specific challenges associated with common property resources. These resources are characterized by "non-exclusion," referring to the difficulty of limiting access to them, and "rivalry," meaning that one agent's exploitation of the resource reduces opportunities for others to exploit it. For example, hunting game in a public forest may be difficult to prevent or control, and the consumption of prey by one individual deprives others of enjoying that product. In the case of common property resources, the incentives for conservation are even lower. Without coordination mechanisms, the limited motivation to protect the ecosystems results in suboptimal levels of ecosystem services. Additionally, agents typically do not maximize provisioning services. In other words, when one individual uses a resource sustainably, it may not significantly contribute to conservation efforts.

## When property rights are diffuse, conservation incentives are limited because the benefits occur in the future and their beneficiaries are uncertain

When property rights are diffuse, conservation incentives are limited because the benefits occur in the future and their beneficiaries are uncertain. In the case of public lands, for example, diffuse property rights manifest because in many cases they are de facto inhabited and used for long periods of time. Indigenous communities with legitimate rights to these lands and traditional livelihoods coexist and are threatened by land appropriations and the establishment of intensive economic activities. Since users do not have formal property rights over the use or sale of the lands they manage, they have little incentive to invest in their conservation. Policies to transfer property rights over public lands can alleviate these incentives because future returns from conservation efforts can be partially capitalized by beneficiaries. However, States must weigh the incentives that this generates in the future: in the absence of accurate information and the ability to maintain control over other territories, these policies may motivate new appropriations of public lands.

State capacity is a key determinant of the impacts of economic activity on ecosystems. This capacity includes both the quality of institutional and regulatory design, i.e., the extent to which these reflect the social costs and benefits of economic activities, and the effectiveness of the state in ensuring adherence to these regulations. Compared to developed economies, countries in Latin America and the Caribbean tend to have less stringent environmental regulations and, above all, lower capacity to enforce existing norms.

## Countries in LAC exhibit lower state capacity than developed economies to enforce environmental regulations and to avoid the impacts of economic activity on ecosystems

When state capacities to monitor and enforce adherence to regulations are limited, ecosystem protection regulations are usually ineffective. Furthermore, dynamics adverse to conservation can occur: as intensive exploitation is undertaken, leading to significant degradation, the value of conserving the ecosystem decreases, resulting in reduced political will to invest in its protection. For example, if illegal extraction of commercially valuable timber in a protected forest has caused excessive degradation, policymakers may be more inclined to further decrease monitoring efforts in the region or even remove its protected status. Box 3.8 in the next section illustrates the extent of regulatory effectiveness in halting Amazon degradation, even in the absence of structural regulatory changes.

In the Brazilian Amazon, the illegal appropriation of public lands and subsequent titling by the State is recognized as a significant cause of illegal deforestation and the expansion of the agricultural frontier into the forest. This originates from a complex and inconsistent regulatory framework that has occasionally allowed for the circumvention of conservation norms. For instance, the Rural Environmental Cadastre is a voluntary registry where individuals and companies can declare de facto possession of a land parcel. Although it does not constitute a property right, it has been used in practice to demonstrate the 'years of tenure of the land and its productive use, key elements to property regularization mechanisms. Deforestation of plots is also used as evidence that the landholder has invested resources and labor to increase its value and maintain its productive use (Carrero et al., 2022).

Since environmentally sound practices are typically expensive for production, heterogeneity in environmental protection affects both the distribution of economic activities and the production technology chosen by firms in different regions within the same industry. This has given rise to the phenomenon known as the “race to the bottom” in environmental practices, which refers to the reallocation of polluting practices from developed to less developed economies, enabled by trade integration. While assessing the causal effect of trade integration on the relocation of environmental impacts is challenging, some evidence from the North American Free Trade Agreement associated with the trade of used cars with high environmental footprints and the relocation of polluting industries resulting from the tightening of environmental regulation supports this hypothesis (Davis and Kahn, 2010; Jayachandran, 2022; Tanaka et al., 2022). This phenomenon can lead to further ecosystem degradation and biodiversity loss in Latin America and the Caribbean.

# Policies for the preservation and regeneration of ecosystems and biodiversity

Environmental policies can be categorized into command-and-control policies (i.e., traditional regulatory approaches) and market-based policies. Command-and-control policies operate through permits, prohibitions, and standard setting. Market-based policies seek to change incentives (costs or benefits) so that individuals, communities, and businesses take into account (internalize) the externalities their actions have on the environment. Command-and-control policies include prohibitions or limits on deforestation, as found in forest laws in most countries in the region (see, for example, the case of Brazil in Box 4.6) and, more recently, wetland protection laws.

The establishment of protected areas (PAs) that impose restrictions on economic activity and human settlements, as well as the co-management of publicly owned natural resources with the participation of local communities and other stakeholders, are discussed below. Both are command-and-control policies, but through the allocation of property rights, they can create incentives for the sustainable use of natural resources. Market mechanisms include payment for ecosystem services (PES) programs, environmental certifications and industry agreements, and the reform of subsidies to economic activities that have a negative impact on ecosystems.

Nature-based solutions (NbS) are actions for the protection, management, and restoration of ecosystems that aim to effectively and adaptively address social challenges while simultaneously benefiting people and nature (IUCN, 2023). NbS can be based on command-and-control policies, such as the prohibition of urban development in areas of ecosystem value, or market incentives, for example, with fiscal incentives for the establishment of green areas. Box 3.7 describes the main NbS for urban areas, where they have high potential (Chapter 2 discusses NbS related to the agricultural sector).

## Command-and-control policies

### Protected areas

Protected areas (PAs) are the most frequently used and visible tool for preserving ecosystems and biodiversity. They are geographically defined areas with a clear delimitation, whose main objective is the conservation of nature and the associated ecosystem services and cultural values (Dudley, 2013).

PAs are essential for maintaining the natural functioning of ecosystems, provide refuge for species, and safeguard ecological processes that cannot survive terrestrial or marine areas subject to intense human intervention (Dudley, 2013). By protecting ecosystems, PAs also preserve the ecosystem services. For instance, in Colombia, 31% of the drinking water consumed comes from the National Natural Parks System, which is also a major supplier of water for agricultural irrigation. Peru and Venezuela present similar cases (Bovarnick et al., 2010).

PAs protect monuments and natural spaces of cultural importance, and national parks and wilderness areas that offer opportunities for recreation and relaxation. This protection can have a significant impact on sustainable tourism. PAs cover important natural tourist destinations in Argentina, Costa Rica, Ecuador, Mexico, and Peru. For example, around 70% of international tourists traveling to Argentina and Peru visit a PA (Bovarnick et al., 2010).

## Box 3.7
Nature-based solutions for cities

Nature-based solutions (NbS) are a cost-effective alternative response to many of the challenges of climate change adaptation in Latin American and Caribbean cities. In addition, they have the potential to provide environmental co-benefits, reducing the impact of cities on the ecosystems in which they are inserted, providing recreational and cultural value to urban residents and contributing to climate change mitigation.

An important ecosystem service that nature can provide in urban environments is temperature regulation. The presence of urban forests, street trees, and green terraces allow local temperature attenuation, mainly through shading and evapotranspiration. Thus, the temperature in urban green areas can be on average 1°C lower than in the surrounding area during the daytime (Bowler et al., 2010). Temperatures on roofs covered with green terraces can be 17-22°C lower than conventional ones and their widespread adoption can reduce the ambient temperature across the city by up to 3°C (General Services Administration, 2011; Santamouris, 2014). This thermal regulation capacity can reduce energy demand for cooling which, together with the carbon sequestration of urban trees, contributes to climate change mitigation (Chen et al., 2023).

Green areas and green roofs also help reduce the risk of stormwater flooding by increasing groundwater infiltration and slowing down rainfall runoff. NbS for water regulation aim to restore the hydrology of urban environments to pre-urbanization conditions, thereby reducing the required capacity of traditional drainage infrastructure. Analyses of urban green areas considering initial investment and maintenance costs consistently reveal the cost-effectiveness of these initiatives (McPherson et al., 2005).

Mangroves, coral reefs, and salt marshes provide coastal protection services to coastal urban centers from flooding and erosion caused by storm surges. Coral reefs and salt marshes reduce the speed and height of waves reaching the shore, minimizing erosion (Narayan et al., 2016). The dense roots of mangroves absorb wave energy, while promoting sedimentation, regulating nutrient inputs to the oceans. The restoration of these coastal ecosystems is also a cost-effective solution when compared to alternative traditional infrastructure. For example, reefs can be equally effective, while the cost of restoration is a fraction of the cost of constructing artificial defenses (Ferrario et al., 2014).

To enhance the use of NbS, it is necessary to give visibility to the benefits that nature can provide in urban environments. Moreover, decision-makers must be given measurement tools so they can accurately assess these benefits and instruments to overcome financial constraints that limit their adoption. In particular, the recreational and cultural value of urban nature is often reflected in an increase in the value of nearby properties (Ardeshiri et al., 2016; Roberts et al., 2022; Wu et al., 2017). Therefore, instruments to capture increases in land value, such as property taxes, may be a powerful tool to enable these investments (Blanco Blanco et al., 2016; Central Park Conservancy, 2015; Escorza et al., 2023).

## Protected areas contribute to preserve the services provided by ecosystems: 31% of the drinking water consumed in Colombia comes from its National Natural Park System

In practice, PAs can vary significantly, including differences in their names across countries. To facilitate monitoring, the International Union for Conservation of Nature (IUCN) established the categorization framework presented in Table 3.2.

The IUCN categories are often summarized as strict conservation areas (I-IV) and multiple-use areas (V-VI). Strict conservation PAs significantly restrict economic activities and human settlements, although some allow visitor access for recreational purposes (II-IV). On the other hand, multiple-use PAs accept sustainable productive activities and may have significant human settlements.

The importance of PAs in countries' conservation strategies is reflected in the international commitments assumed under the United Nations Convention on Biological Diversity. In 2010, countries defined the Aichi Targets for 2020, and in 2020 parties agreed upon the Kunming-Montreal Global Biodiversity Framework Targets for 2030 (see Chapter 4). Aichi Target 11 commits countries to cover at least 17% of their terrestrial and inland water areas and 10% of their marine and coastal areas as PAs by 2020. This target stipulates that PAs should have effective and equitable management, be representative of existing ecoregions, and be well-connected and integrated into larger landscapes. In the Global Biodiversity Framework, countries increased the ambition through Target 3, which aims to protect at least 30% of the world's terrestrial, marine, and freshwater ecosystems by 2030.[11] However, this target may be conservative, although the available estimates are very uncertain. According to an IUCN study, it is necessary to conserve between 30% and 70% of the planet's total surface area to halt and reverse biodiversity loss and contribute to climate change response (Woodley et al., 2019).

**Table 3.2**
International Union for Conservation of Nature (IUCN) protected area categories

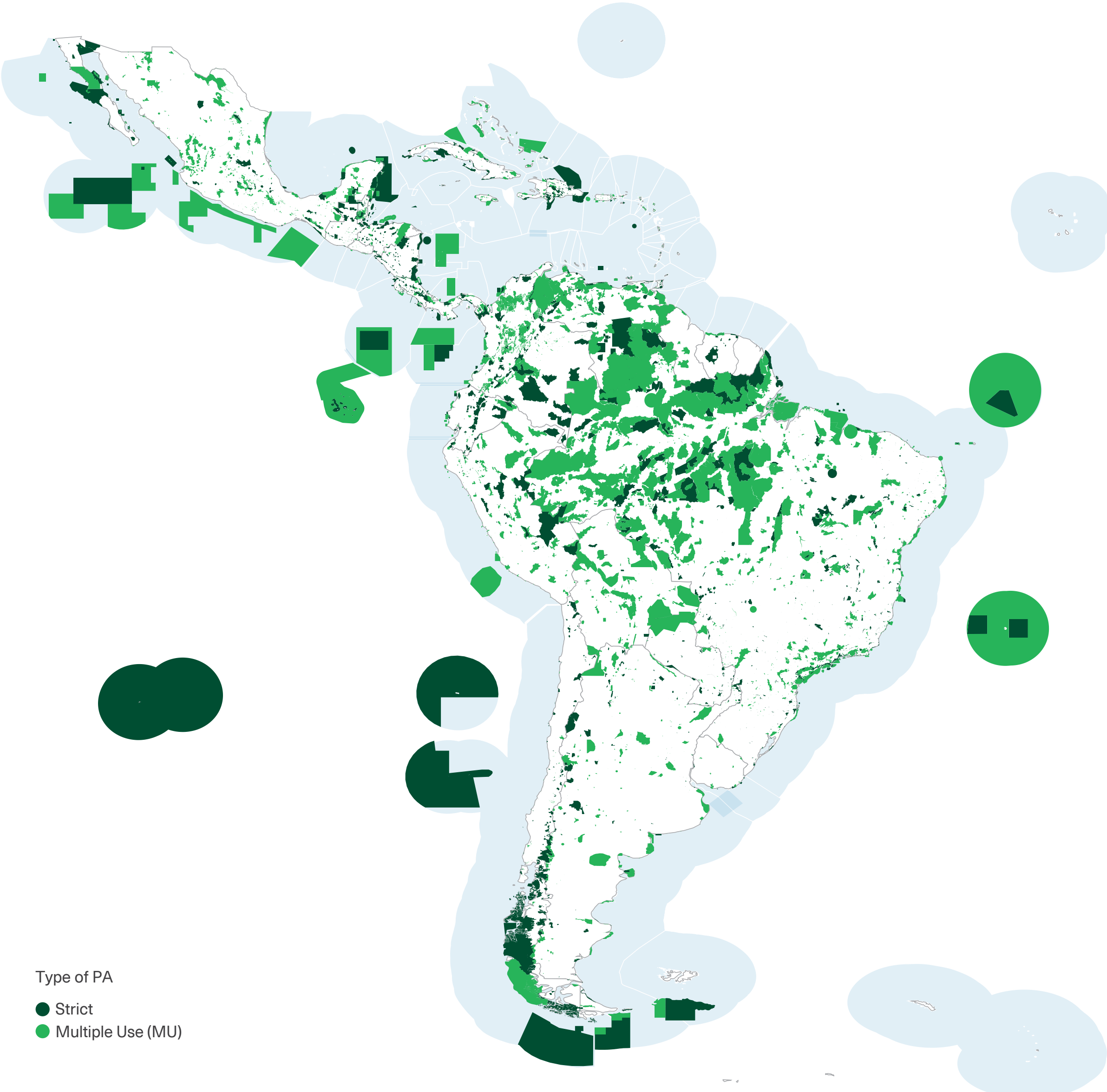
| Category | Main management objectives |
|---|---|
| Category Ia – Strict nature reserve | Protection of biodiversity and geological or geomorphological features. Enable scientific research and monitoring. |
| Category Ib – Wilderness Area | Conservation of unmodified or slightly modified areas. |
| Category II – National park | Protection of large-scale ecological processes and recreation. |
| Category III – Natural monument or natural feature | Protection of a specific natural monument. |
| Category IV – Habitat or species management area | Protection of habitats or specific species that usually require active interventions. |
| Category V – Protected landscape or seascape | Landscape and seascape conservation and recreation. |
| Category VI – Protected area with sustainable use of natural resources | Conservation of ecosystems and habitats through sustainable management of natural resources. |

**Source:** Authors based on Dudley (2013).

11 Target 3 allows for these levels of protection to be achieved either through PAs or through another mechanism called "other effective area-based conservation measures" (OECMs). So far, criteria have not been defined to establish which areas can be classified as OECMs.

Scan this QR code to watch the video of CAF's impact on the conservation and strengthening of protected areas in Latin America and the Caribbean.

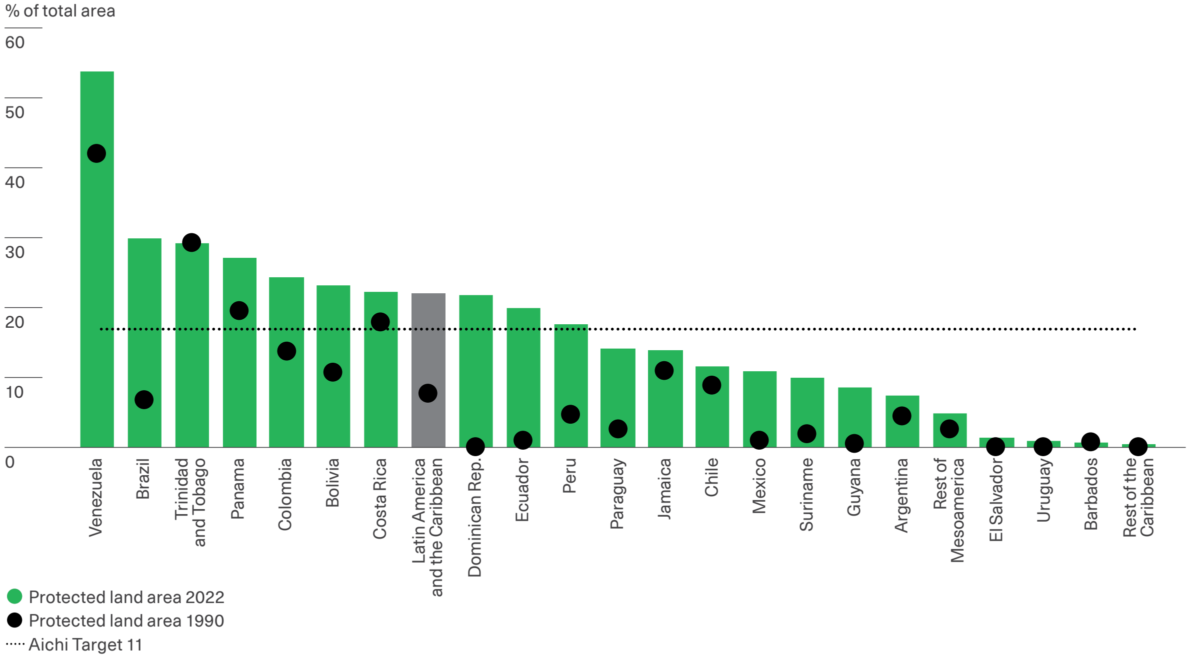
**Graph 3.6**
Distribution of protected areas in Latin America and the Caribbean by level of protection




**Note:** The graph includes all areas with national designation. They are divided into strict Aps and multiple-use Aps (UM). Strict Aps are classified under categories I to IV of the IUCN. The remaining areas are considered multiple-use Aps (UM). Exclusive economic zones are shown in blue. Further details on the treatment of protected areas data can be found in the online appendix of this chapter.

**Source:** Authors based on geo-referenced data from Protected Planet (UNEP-WCMC and IUCN, 2022) and of exclusive economic zones from Flanders Maritime Institute (2019).

**Graph 3.7**
Terrestrial protected areas by country




**Note:** The graph shows the proportion of protected land areas in 1990 (circles) and in 2022 (bars) with respect to the total land area of each country. The last bar shows the total for LAC. All protected areas with national type designation from the Protected Planet database are included. The list of countries considered in the graph and more details on the treatment of PA data can be found in the online appendix of this chapter.

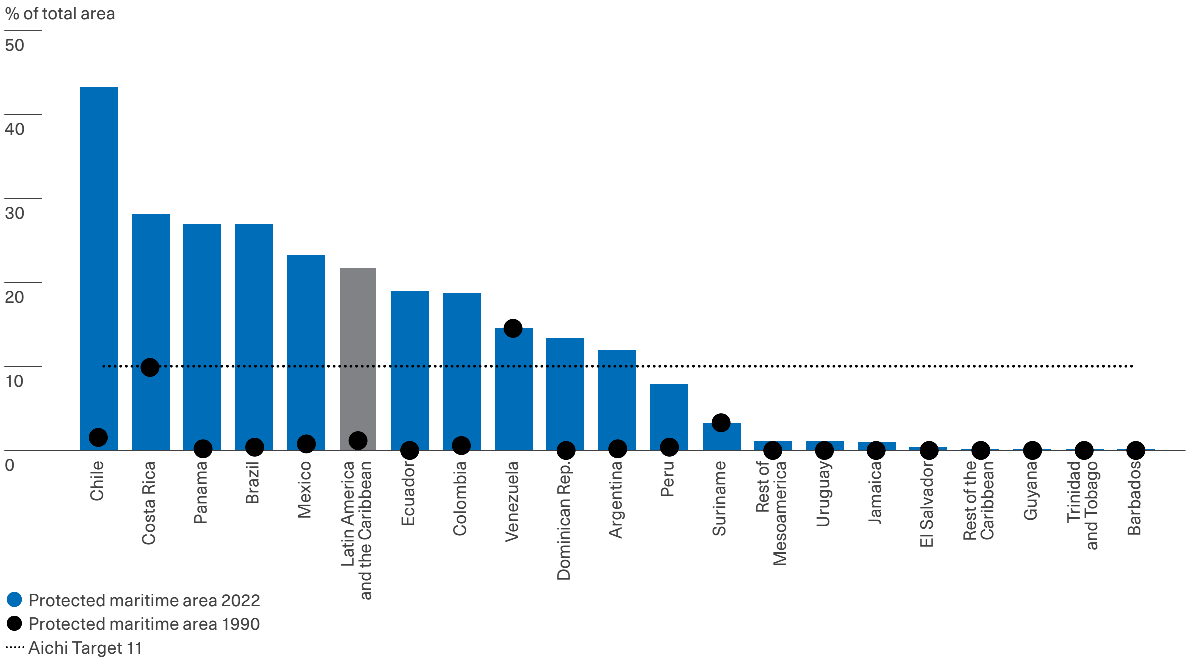
**Source:** Authors based on Protected Planet data (UNEP-WCMC and IUCN, 2022).

## Currently, there are more than nine thousand Protected Areas in Latin America and the Caribbean, which cover 22% of their land surface and a similar percentage of their territorial marine waters

Currently, there are 9,154 PAs in Latin America and the Caribbean (see Graph 3.6), covering 22% of the region's terrestrial surface and a similar percentage of its marine territorial waters. These figures make Latin America and the Caribbean one of the regions with more PAs. Globally, approximately 15% of the land surface and 7.5% of the oceans are classified as PAs (IPBES/IPCC, 2021).

The prevalence of PAs varies among countries in the region (see Graphs 3.7 and 3.8). Generally, Mesoamerican and South American countries exhibit a higher PA coverage compared to Caribbean countries (with exceptions such as the Dominican Republic and Trinidad and Tobago). In total, ten out of the 20 countries with available data in the region have achieved Aichi Target 11 for land protection, and another ten have achieved it for marine areas. In most cases, these levels of protection have been the result of the expansion of PAs over the past 30 years, particularly in marine areas.

**Graph 3.8**
Protected maritime areas by country



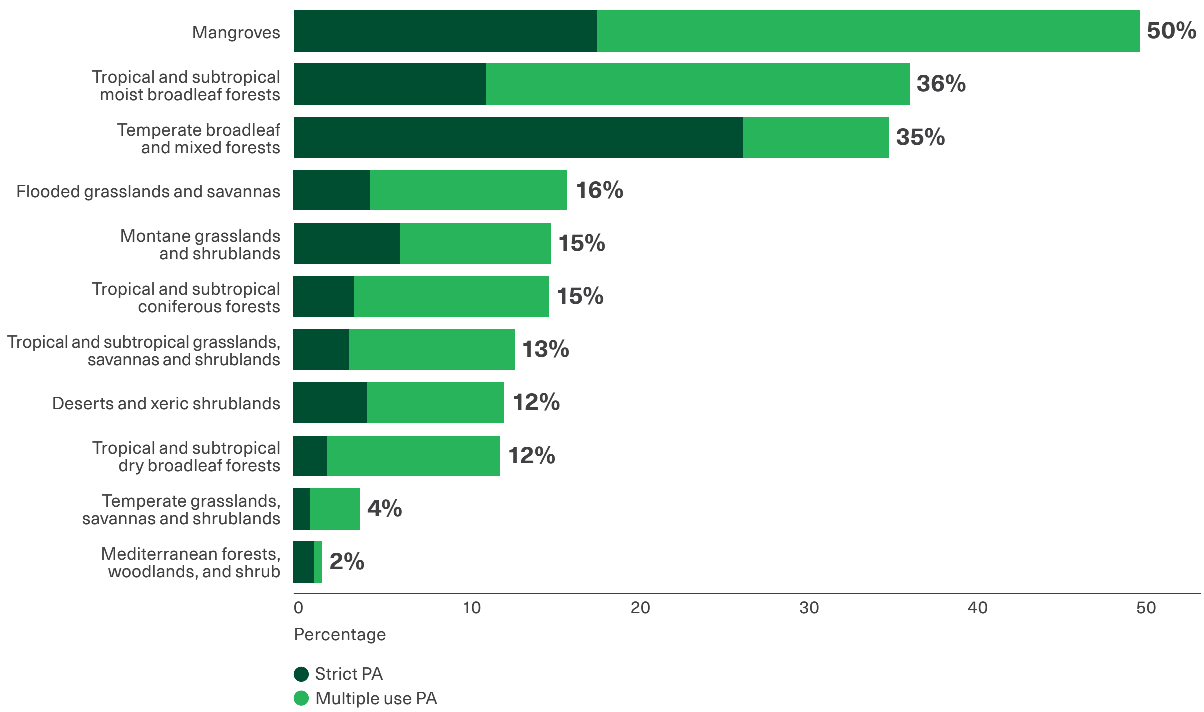

**Note:** The graph shows the proportion of protected maritime areas in 1990 (circles) and in 2022 (bars) with respect to the total maritime area of each country. Exclusive economic zones are taken as maritime areas and all PAs with national type designation from the Protected Planet database are included. The list of countries considered in the graph and more details on the treatment of PA data can be found in the online appendix of this chapter.

**Source:** Authors based on georeferenced data from Protected Planet (UNEP-WCMC and IUCN, 2022) and data on Exclusive Economic Zones from the Flanders Maritime Institute (2019).

Biodiversity conservation requires that all biomes be represented in PAs. In Latin America and the Caribbean, the biomes with the greatest coverage are mangroves (with 50% of their area protected), tropical rainforests (36%) and temperate forests (35%), while in the rest of the biomes PA coverage is less than 17% (see Graph 3.9). Mangrove and tropical rainforest cover is particularly relevant for climate change response, as they have high carbon sequestration rates and, in the case of mangroves, provide important adaptation services to coastal populations (IPBES/IPCC, 2021). It is also important that PAs cover the key biodiversity areas (KBAs), which are sites that contribute significantly to the global persistence of biodiversity (IUCN, 2016). In the region, 2300 KBAs have been identified, totaling 3.2 million km$^2$ of land area, 56% of which are within a PA (Álvarez Malvido et al., 2021).

**The biomes with the highest coverage of protected areas are mangroves (with 50% of their surface area protected), tropical rainforests (36%) and temperate forests (35%)**

**Graph 3.9**
Percentage of natural protected areas by biome




**Note:** The graph shows the percentage of protected land in LAC for each of the biomes identified in Ecoregions2017. It includes all areas with a national designation and is divided into strict and multiple-use protected areas (PAs). Strict PAs are classified by IUCN categories I to IV. The remaining areas are considered multiple-use PAs. Refer to the online appendix of this chapter for further details on the treatment of PA data. The countries represented in the graph are the 33 countries belonging to the Community of Latin American and Caribbean States (CELAC).

**Source:** Own elaboration based on data from Protected Planet (UNEP-WCMC and IUCN, 2022) and Ecoregions2017 (Dinerstein et al., 2017).

Latin America and the Caribbean is the region with the highest coverage of multiple-use PAs in the world (Alpízar, Carlsson et al., 2020). As shown in Table 3.3, 30% of the protected land area in LAC is under strict conservation and the remaining 70% under multiple uses, while for marine PAs these figures are 52% and 48%, respectively. However, the distribution of PAs by type of use varies considerably among countries.

The specialized literature indicates that PAs have generally had a moderate effect on reducing deforestation, which is the main outcome studied (Alpízar et al., 2020; Blackman et al., 2014). However, this impact varies depending on the context. Two factors help explain these results.

First, a group of PAs tends to be in isolated regions or those with low exploitation value (Baldi et al., 2017; Joppa & Pfaff, 2009; Pfaff et al., 2009). The impact of isolated PAs is modest because the ecosystems where they are located are not subject to deforestation, either because they are far from significant human settlements or because their terrain is very steep. The selection of these locations may be due to the lower political and economic costs of establishing a PA where there are no groups opposing its establishment due to the restrictions on economic activities it entails. A similar dynamic is observed in marine PAs, which tend to be in areas of little interest for fishing, reducing their ability to protect vulnerable species (IPBES/IPCC, 2021).

**Table 3.3**
Terrestrial and marine protected areas by country

| | Land areas | | | Maritime areas | | |
|---|---|---|---|---|---|---|
| | **Protected area (thousands of ha)** | **Protected area (%)** | **Strict (% of PA)** | **Protected area (thousands of ha)** | **Protected area (%)** | **Strict (% of PA)** |
| Argentina | 20,329 | 7.3 | 34 | 12,881 | 12.0 | 82 |
| Barbados | 0.2 | 0.5 | 75 | 1.3 | 0.0 | 100 |
| Bolivia | 25,240 | 23.2 | 2 | | | |
| Brazil | 252,417 | 29.8 | 21 | 98,956 | 26.9 | 13 |
| Chile | 8,534 | 11.6 | 98 | 158,217 | 43.1 | 97 |
| Colombia | 27,515 | 24.3 | 55 | 13,721 | 18.8 | 24 |
| Costa Rica | 1,144 | 22.3 | 66 | 16,589 | 28.1 | 35 |
| Ecuador | 5,075 | 19.9 | 84 | 20,669 | 19.0 | 2 |
| El Salvador | 25 | 1.2 | 30 | 41 | 0.4 | 0 |
| Guyana | 1,779 | 8.4 | 0 | 3 | 0.0 | 0 |
| Jamaica | 150 | 13.8 | 56 | 284 | 1.0 | 11 |
| Mexico | 21,216 | 10.8 | 20 | 74,299 | 23.3 | 38 |
| Panama | 1,998 | 27.0 | 54 | 8,948 | 27.0 | 7 |
| Paraguay | 5,677 | 14.2 | 46 | | | |
| Peru | 22,819 | 17.7 | 47 | 6,871 | 8.0 | 0 |
| Dominican Republic | 1,058 | 21.8 | 81 | 4,804 | 13.4 | 100 |
| Suriname | 1,422 | 9.8 | 100 | 441 | 3.3 | 18 |
| Trinidad and Tobago | 148 | 29.1 | 96 | 1 | 0.0 | 100 |
| Uruguay | 135 | 0.8 | 15 | 197 | 1.2 | 38 |
| Venezuela | 48,991 | 53.8 | 46 | 6,905 | 14.6 | 13 |
| Rest of Caribbean | 47 | 0.3 | 49 | 396 | 0.2 | 24 |
| Rest of Mesoamerica | 1,801 | 4.8 | 68 | 706 | 1.2 | 76 |
| **Latin America and the Caribbean** | **447,519** | **22.0** | **30** | **424,931** | **21.6** | **52** |

**Note:** The table shows the terrestrial and marine protected areas' surface area in each country, in thousands of hectares, and as a percentage of the total national territory. It also includes the proportion of strict protected areas as a percentage of the total terrestrial and marine protected areas. The graph considers the exclusive economic zones as the total national sea territory. This analysis includes all the areas with a national classification of PAs. Strict protected areas are classified by the IUCN into categories I to IV, inclusive. Please refer to the methodological online appendix of this chapter for more details on the treatment of protected area data. The countries included in the "rest of The Caribbean" and "rest of Mesoamerica" groups can also be found in the online appendix of this chapter.

**Source:** Authors based on georeferenced data from Protected Planet (UNEP-WCMC and IUCN, 2022) and exclusive economic zone data from Flanders Maritime Institute (2019).

Second, in cases where PAs are located in areas with human pressure on ecosystems, institutional capacity problems can limit the effective protection that PA designation provides against the proliferation of illegal activities. Part of the institutional weakness is caused by the budgetary constraints that most PA agencies in the region are subject to (Bovarnick et al., 2010). The problem of ineffective PA protection becomes more pressing when the institutional framework creates incentives that favor deforestation and land occupation within those areas, such as amnesties that allow the issuance of private property titles to those who prove possession of specific lands.

Pressure on PAs can lead to formal reductions in their size, for example, when deforestation is followed by pressure from local stakeholders to remove the conservation status. Keles et al. (2020) document that, during the period 2001-2005, deforestation processes in PAs located in the Brazilian Amazon increased the probability of a reduction in their surface area. When the State fails to effectively protect a PA, over time, ecosystem degradation reduces its conservation value, which reduces incentives to maintain the protected area status.

Climate change is affecting PA management (IPBES/IPCC, 2021) due to an increase in the number and intensity of extreme weather events (e.g., droughts and fires). Additionally, rising temperatures lead to species migration (in search of higher altitudes, for example), which can alter the species composition within PAs, either because some species whose protection may have motivated the establishment of PAs migrate or due to the emergence of new species. This migration highlights the importance of PAs being part of a connected system through habitat corridors, which prevent ecosystem fragmentation and allow species to migrate to areas with better climatic conditions.

Strict restrictions aim to maximize the conservation impact of PAs. However, the prohibition of economic activities imposes costs on the local population, particularly when they depend on the natural resources within these areas. These costs often translate into opposition from local communities to the establishment of PAs and the proliferation of illegal productive activities, undermining the effectiveness of protection. They also contribute to the existence of the so-called leakage effect, which refers to the relocation of deforestation and biodiversity loss-generating activities from within PAs to their surrounding areas (Ford et al., 2020; Fuller et al., 2019).

Multiple-use protected areas respond to the goal of achieving a balance between conservation objectives and local development. Like other co-management mechanisms (see the next subsection), multiple-use protected areas can strengthen the capacities and incentives of local communities and other actors to participate in the conservation of natural resources through the allocation of property rights and the promotion of sustainable economic activities. The evidence in this regard is encouraging.

In a study commissioned for this report, Rico-Straffon et al. (2022) found that multiple-use protected areas in Peru are as effective as, or even more effective than, strictly protected areas in preventing deforestation. These findings are consistent with other studies conducted in the region, such as Sims and Alix-Garcia (2017) and Sims et al., (2014) for the case of Mexico, Pfaff et al. (2009) for Costa Rica, and Robalino et al. (2015) for Brazil, as well as studies conducted worldwide (Nelson and Chomitz, 2011). Furthermore, these findings complement the positive effects found of multiple-use protected areas in reducing poverty in local communities (Bocci et al., 2018).

The presence of human populations in protected areas is a reality in most countries in Latin America and the Caribbean (see Table 3.4). This may be due to areas with pre-existing local communities being declared protected areas (highlighting the importance of the multiple-use protected area concept. Alternatively, informal settlements may have located later, taking advantage of the lack of effective protection in these areas. In any case, the existing population density can affect the capacity of protected areas to effectively achieve their conservation objectives. As reported in Table 3.4, 95% of the surface area of protected areas in the region can be considered uninhabited, 4% has the population density of a rural area, and 1% reaches the density of an urban area. Settlements with a population density of a rural area can sustainably coexist with the ecosystems and biodiversity protected within the PAs, particularly for areas that do not require strict protection. However, this is not the case for settlements with urban density within protected areas, as their presence suggests problems with effective protection.

**Table 3.4**
Population of Latin American and Caribbean countries residing in terrestrial protected areas and in their periphery

| Country | Resident population in PA | PA area by population density (%) | | |
|---|---|---|---|---|
| | No of inhabitants | Uninhabited | Rural | Urban |
| Argentina | 481.385 | 97.3 | 2.5 | 0.2 |
| Barbados | 636 | 3.4 | 48.2 | 48.4 |
| Bolivia | 3,334,371 | 97.6 | 1.9 | 0.5 |
| Brazil | 21,093,919 | 96.8 | 2.8 | 0.4 |
| Chile | 54.504 | 99.3 | 0.6 | 0.1 |
| Colombia | 5,989,043 | 82.5 | 15.0 | 2.4 |
| Costa Rica | 73.579 | 89.9 | 9.4 | 0.7 |
| Ecuador | 176.297 | 98.0 | 1.9 | 0.1 |
| El Salvador | 12.263 | 67.5 | 24.0 | 8.5 |
| Guyana | 1.188 | 99.9 | 0.1 | 0.0 |
| Jamaica | 726.970 | 75.8 | 9.0 | 15.2 |
| Mexico | 4,868,679 | 91.2 | 6.7 | 2.1 |
| Panama | 79.933 | 94.9 | 4.5 | 0.6 |
| Paraguay | 133.784 | 98.2 | 1.6 | 0.2 |
| Peru | 166.522 | 99.1 | 0.8 | 0.1 |
| Dominican Republic | 249.850 | 85.9 | 11.5 | 2.6 |
| Suriname | 733 | 99.9 | 0.1 | 0.0 |
| Trinidad and Tobago | 32.592 | 81.3 | 15.5 | 3.2 |
| Uruguay | 786 | 98.5 | 1.4 | 0.1 |
| Venezuela | 13,430,159 | 94.9 | 3.7 | 1.4 |
| Latin America and the Caribbean | 53,074,527 | 95.4 | 3.8 | 0.7 |

**Note:** The first column of the table shows the number of people living within the protected areas (PA). The following three columns indicate the proportion of the PA's surface area that is uninhabited, the proportion of PAs surface area that has a rural population density, and the proportion of PAs area that has an urban population density. The classification is as follows: (i) uninhabited for areas with a population density < 5 people/km$^2$; (ii) rural for areas with a population density >=5 people/km$^2$ and <150 people/km$^2$, and (iii) urban for areas with a population density >= 150 people/km$^2$. These estimates were derived from georeferenced population data from GHS (Schiavina et al., 2022), aggregated at a resolution of 1 km. These data were combined with the Georeferenced World Database of Protected Areas (BDMAP). More details on the estimation methodology are available in the online appendix of this chapter.

**Source:** Authors based on data from Protected Planet-BDMAP (UNEP-WCMC and IUCN, 2022) and GHS-POP (Schiavina et al., 2022).

PAs encompasses a continuum ranging from areas exclusively managed by the State with a single conservation objective to those that follow multiple-use and shared management models. Currently, estimates indicate that at least 6% of protected areas in Latin America and the Caribbean are managed by indigenous peoples and local communities, 15% by the private sector, 57% by national or subnational governments, and 2% have shared governance models, while there is no data for the remaining 20% (Álvarez Malvido et al., 2021).

Relatedly, various initiatives inspired by the multiple-use PA management model have been launched to protect privately or communal owned natural areas (which may not have the legal status of a protected area). For example, in Argentina, Brazil, Chile, Colombia, and Paraguay, there has been an impetus to develop private networks of protected areas (Alpízar, Carlsson et al., 2020). Under this model, private landowners commit to conservation goals in exchange for fiscal incentives and other types of support (such as technical assistance and tourism promotion). In Mexico, the Voluntary Conservation Areas program allows private and communal properties (known as *ejidos*) to access funding for ecotourism and carbon sequestration projects and receive more support to prevent illegal logging and hunting (Alpízar, Carlsson et al., 2020).

In summary, protected areas are a conservation tool that has significantly expanded in use over the past 30 years. Given international commitments, the coverage of PAs is expected to grow in the future. Measures to enhance the effectiveness of PAs encompass reviewing the criteria used to determine their location, strengthening the institutional capacity and the financing for the responsible management agencies, and reinforcing the enforcement of related regulations. Additionally, where the conservation objectives allow, other measures include expanding the multiple-use model of protected areas through the involvement of local communities, the private sector, and other actors in their administration.

### Co-management: participation of local communities and other stakeholders

Co-management refers to the transfer, by the government, of a certain degree of control over common-use natural resources (such as publicly owned forest, fisheries, or water resources) to local communities or other stakeholders . The transfer can range from granting the rights to exploit a resource, often on an exclusive basis, to giving the authority to manage a geographic area, usually without the possibility of alienating the rights (Blackman et al., 2014). The allocation of rights typically targets communities or collectives and is contingent upon adopting sustainable practices in the use of resources. Examples of co-management are multiple-use PAs, community concessions such as exclusive artisanal fishing zones, and the territories of indigenous or Afro-descendant peoples in countries such as Bolivia, Brazil, and Colombia (which are recognized by the constitutions of these countries as common property of these peoples). Figure 3.3 shows the types of rights that can be granted over common-use resources.

**Co-management is the transfer of rights to exploit a natural resource or to manage a publicly owned area to local communities or other actors**

is compatible with conservation and local development objectives. The allocation of property rights aims to prevent overexploitation associated with the competition among multiple stakeholders over common-use resources. Property rights incentivize sustainable resource use by providing certainty about the returns on conservation efforts. They also encourage the participation of local communities in detecting and reporting illegal extraction activities and land-use changes that affect co-managed resources.

Allocating rights at the community or collective level, rather than individually, seeks to leverage the organizational structure and social bonds within communities to address the underlying coordination challenge of common-resource exploitation.

Co-management is also a tool that has enabled to legally recognized the rights of rural communities and indigenous peoples over the territories and resources they inhabit and that sustain their way of life and cultural identity.

**Figure 3.3**
Property rights over common-pool resources


**Source:** Authors based on Ostrom and Schlager (1996), taken from Maldonado and Moreno-Sánchez (2023).

The potential of co-management to contribute to forest conservation in the region is significant because most forests are publicly owned. This is the case for 63% of South America's forest area, 81% of the Caribbean, and 37% of Central America (FAO, 2020).

In a study commissioned for this report, Tanner and Ratzke (2022) analyze the impact of the Sustainable Use and Mangrove Custody Agreements (AUSCM, for its acronym in Spanish) on conservation in Ecuador. They found evidence that their adoption reduces the loss of this ecosystem. This program emerged in 1999 as a response to intense deforestation of mangrove forests, mainly driven by the establishment of shrimp aquaculture farms (since 1970, Ecuador has lost between 30% and 40% of its mangrove area). By deforesting, the aquaculture farms deplete the population of red crabs and cockles, which are vital for the livelihoods of local communities. The AUSCM grants exclusive rights to local associations for the exploitation of mangrove resources for a period of ten renewable years. In return, these associations must present a sustainable management plan and carry out monitoring and conservation activities. Non-governmental organizations (NGOs) and universities play an active role by providing technical training to communities in the legal processes for association formation and in filing complaints against illegal deforestation.

## Box 3.8
### Policies to reduce deforestation in the Amazon[a]

Policies to reduce deforestation in the Amazon in Brazil are of particular interest to the rest of the region, both for their innovative nature and for the available evidence regarding their effectiveness.

Deforestation of the Amazon began on a large scale in Brazil during the 1970s, mainly due to the expansion of the agricultural sector. This process was driven both by the increase in global demand for food and energy, described in the section "Causes of ecosystem degradation and associated economic sectors" and by policies to promote economic activity in the Amazon biome, including tax incentives and infrastructure projects.

Faced with the advance of deforestation, the Brazilian government began to adopt a series of command-and-control policies beginning in the 1990s. These included the enactment of laws against deforestation; the expansion of the PA network and the allocation of land use rights to indigenous peoples; and the creation and strengthening of government agencies in charge of enforcing the new regulations. These policies were later joined by initiatives based on market mechanisms (discussed in the subsection of the same name).

In terms of the institutional framework, the Federal Environmental Supervision Agency (IBAMA, for its acronym in Portuguese) was created in 1989 and, a year later, the Ministry of the Environment, the two main agencies in charge of implementing environmental policy. In the legislative field, in 1996, the government increased the required area that landowners in the Amazon biome must preserve in its natural state to 80% (this obligation, known as "Legal Reserve," was first introduced in the Forestry Code in 1965). In 1998, the figure of "environmental crime" was approved, which punish deforestation with penalties ranging from fines to imprisonment. Nevertheless, deforestation in the Amazon continued at the same rate.

Efforts were redoubled in 2004 with the creation of an inter-ministerial working group in charge of the Action Plan for the Prevention and Control of Deforestation in the Amazon (PPCDAm, for its acronym in Portuguese). This group launched a strategy based on the expansion of the PAs; the creation of DETER, a real-time deforestation monitoring system based on satellite data; and the strengthening of IBAM''s budget and capacity for action. Fines for deforestation were also increased in the following years.

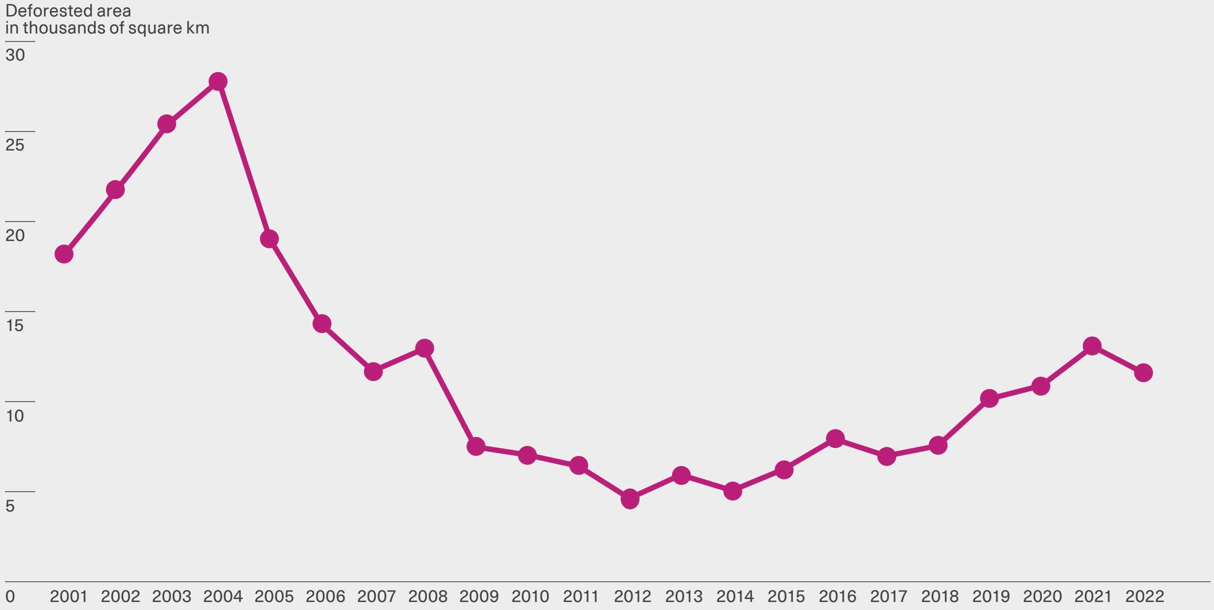
Today, land tenure in the Brazilian Amazon is distributed between indigenous people'' territories and conservation sites (50%), public forests owned by the national and subnational governments (30%), and private farms (20%). Deforestation is prohibited in both protected areas and public forests, while owners of private farms must conserve vegetation in its native state on at least 80% of their land area. As a consequence of these strict regulations, almost all deforestation(between 96% and 97%) is illegal (Valdiones et al., 2021). Most of this takes place in public forests and is composed of events that are relatively small in scale. Estimates indicate that deforestation of areas of less than 50 ha accounts for about half of total deforestation.

Despite implementation challenges, a number of studies show that IBAMA inspections have been an effective tool for reducing deforestation (Assunção, McMillan, et al., 2019; Assunção et al., 2022; Assunção and Rocha, 2019; Ferreira, 2023) and have even had positive effects on forest regeneration (Assunção, Gandour, et al., 2019; Oliveira Filho, 2020). The DETER monitoring system allowed IBAMA to identify areas where forest fires occur and act accordingly in a timely manner (mobilizing agents to identify those responsible while they are still on site).

In addition to the increase in resources, IBAM''s effectiveness was enhanced by focusing efforts on municipalities at high risk of deforestation and improving the cadastral system (which makes it possible to identify the owners of deforested land without the need for on-site inspections).

The experience of IBAMA and DETER shows that it is possible to reduce deforestation in the Amazon. In this task, technology can play a very relevant role for real-time monitoring of deforestation and improvement of land registries (although clarification of land tenure is also a political process). It is also essential that the agencies responsible for inspecting and punishing deforestation have sufficient institutional capacity to do their job. This is no small challenge given the variation in macroeconomic and political conditions in many countries in the region. As Graph 1 shows, deforestation declined starting in 2004, after the creation of the PPCDAm. It then rebounded after the economic crisis that Brazil experienced starting in 2014. This brought significant budget cuts for IBAMA and other agencies with environmental responsibilities (the operating expenditure of this entity in the Amazon was reduced by 40% in real terms between 2014 and 2020).

**Graph 1**
Annual deforestation in the Brazilian Amazon




**Note:** The graph shows the number of km$^2$ of forest deforested each year in the Brazilian Amazon.
**Source:** Ferreira (2023) based on data from PRODES/INPE (PRODES/INPE, 2023).

a. This box is based on the document “Amazon deforestation: drivers, damages, and policies” prepared by Alipio Ferreira as part of the inputs commissioned for this report.

Co-management can also contribute to develop a sustainable fisheries sector and reverse the patterns of overexploitation that characterize it. Community-based management is relevant to fisheries because 90% of the region's motorized fishing fleet consists of small-scale vessels, which account for about one-third of total catches and approximately half of the commercial value of fisheries (De Oliveira Leis et al., 2019). However, specific regulations for industrial fishing are also necessary. In Latin America and the Caribbean, there is a diversity of experiences with communal fishing rights, which can be categorized as: i) territorial privileges or concessions granted to fisher organizations (e.g., fishing cooperatives in Mexico or fishing communities in Chile); ii) territorial communal rights granted to indigenous or traditional populations (e.g., marine extraction reserves in Brazil, collective territories for Afro-descendant communities, and exclusive artisanal fishing zones in Colombia); and iii) fishing quotas and access limits (e.g., the Galapagos Islands in Ecuador) (Maldonado and Moreno-Sánchez, 2023). Depending on the local context, fishing quotas can also be allocated to individuals and be tradable, so that the most efficient fishers can catch the highest number of fish (Blackman et al., 2014).

Allocating rights to communities or collectives over common-use resources presents implementation challenges. These include the organizational capacity and social cohesion of local communities, prevailing poverty levels, dependence on natural resources (which hinders the transition to sustainable use), environmental conditions, and the existence of a rule of law that effectively ensures compliance with the granted rights (Blackman et al., 2014; Maldonado and Moreno-Sánchez, 2023).

The private sector can also play an active role in co-management models, with forest concessions being the main example. In Peru, the Constitution states that all forests are the property of the State. In 2000, the Peruvian Congress passed a law that led to a series of auctions in which over 500 concessions were granted to private companies, covering more than seven million hectares (around 10% of the total forest area). A recent study found that these concessions helped to reduce deforestation by about 4% compared to similar areas without concessions (Rico-Straffon et al., 2023). The authors of the study suggest that the limited impact may be due to failures in complying with the environmental regulations outlined in the concessions contemplated in the concessions The latter underscores the importance of state capacity as a determinant of the effectiveness of these policies.

## Market mechanisms

### Payments for ecosystem services

Payments for ecosystem services (PES) are a tool to compensate individuals and communities who contribute to the provision of these services through conservation and regeneration efforts. In a nutshell, a PES program involves the establishment of a quasi-market, with voluntary participation from providers who receive payment from beneficiaries through an administrative body. This payment is contingent either on the flow of a specific ecosystem service or the performance of an activity clearly related to its provision (Engel, 2016; Wunder et al., 2008).

Latin American and Caribbean countries have been at the forefront of global PES adoption, implementing over 250 programs of this kind since the 1990s (Alpízar, Madrigal et al., 2020). Costa Rica and Mexico were pioneers in developing national PES programs, such as the Program for Payment of Environmental Services (PPSA) and the Payment for Hydrological Environmental Services (PSAH). respectively. Colombia, Ecuador, and Peru have followed suit. At the subnational level, there are initiatives in Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and other countries (Maldonado & Moreno-Sánchez, 2023). Initially, PES programs focused on payment for the protection of water sources. Participants, located in watershed areas, typically received payments for forest protection and management, as well as reforestation. Gradually, programs promoting carbon capture and storage, biodiversity conservation, and scenic beauty have also emerged (Wunder et al., 2008). Most PES programs in the region seek to achieve their objectives through forest conservation and regeneration, although recent initiatives have also targeted agro-landscapes. For instance, Costa Rica, Colombia, and Nicaragua have initiatives that promote integrated silvopasture as a mechanism to restore degraded pasture areas in livestock-dominated landscapes (Gobbi, 2011). National programs are typically financed by taxes, while local programs draw from a wider range of funding sources (e.g., civil organizations, private sector, and water service users).

## Payments for ecosystem services compensate those who contribute to the provision of these services through conservation or regeneration efforts

Available evaluations on the impact of PES indicate that they can be an effective tool for reducing deforestation, the key outcome under study (Alix-Garcia et al., 2012, 2015; Honey-Rosés et al., 2011). However, their effectiveness depends significantly on design, implementation, and context (Alpízar, Madrigal et al., 2020). Some studies have found that PES programs may have minor or no effects on deforestation reduction (Robalino & Pfaff, 2013; Ruggiero et al., 2019; Sánchez-Azofeifa et al., 2007).

To be effective, PES programs must adhere to the principle of additionality, which means they should result in a greater flow of ecosystem services or conservation actions than would prevail in the absence of the scheme. Consequently, PES programs face challenges related to participant selection, verification, and compliance, as well as unintended adverse effects.

Achieving additionality requires the involvement of providers who have control over resources that would have degraded in the absence of the program. From a strictly environmental perspective, PES programs should ideally focus on areas with higher human pressure, often associated with deforestation risks. However, in practice, PES programs often use prioritization criteria beyond environmental considerations, either because they also have non-environmental objectives (typically poverty alleviation) or due to reasons of political economy. For example, Costa Rica's PPSA and Mexico's PSAH programs combine environmental and poverty reduction criteria to define the population eligible to participate. In the latter case, authorities' interest in distributing resources evenly across regions has favored coverage of areas with low environmental degradation risks (Alix-Garcia et al., 2005).

The prices paid by PES programs to participating providers can be determined based on the value of the services they provide or the costs they incur by participating in the program. In practice, the latter criterion is more commonly used (Salzman et al., 2018; Wunder et al., 2008), partly due to the challenges of measuring the value of the provided services.

To incentivize participation, payments to providers must be at least equal to the costs of participation. These costs include both the opportunity cost of the resources being conserved (i.e., the income that the provider would have earned if they had used the resources for another activity) and the direct costs in the case of regeneration or afforestation initiatives. Efficient PES design should consider a pricing structure that aligns with the opportunity costs of potential providers. These costs increase with the demand for land-use change, from conservation to agricultural activities. This means that given a fixed price per conserved area, providers in areas with higher environmental risks have fewer incentives to participate. Wunder et al. (2008) report that national PES programs in developing countries tend to use uniform prices, contrasting with local programs that have greater flexibility in defining tariff structures. An exception is Mexico's PSAH, which introduced differentiated payments based on risk level and ecosystem type (Alix-Garcia et al., 2018).

For a PES to be effective, providers must comply with the agreed-upon actions. In practice, programs typically pay for conservation and regeneration actions (mainly related to land use) rather than the flow of ecosystem services (Salzman et al., 2018; Wunder et al., 2008). On-site inspections are often conducted to monitor these actions. These visits can involve considerable administrative costs, particularly for programs with broad geographic coverage. In this regard, data obtained through remote sensing systems are increasingly viable for monitoring certain actions (e.g., fires). Conditional payments are direct incentives to comply with conservation actions.

PES programs can have adverse effects that compromise their effectiveness or impact local communities. One notable effect is leakage, which refers to the displacement of deforestation (or other degradation actions) from participating areas to non-participating areas. This effect can be particularly relevant when providers only partially participate in the PES program, meaning they receive payments for a proportion of the land they control. For example, Sohngen and Brown (2004) provide evidence from Bolivia, Izquierdo-Tort et al. (2019) and Alix-Garcia et al. (2012) from Mexico, and Giudice et al. (2019) from Peru. Requiring providers to commit to protecting all of their land can help prevent this problem, although it can also increase costs and necessitates comprehensive land ownership records (Wunder et al., 2020). Additionally, the withdrawal of land from agricultural activities induced by PES programs increases the returns from practicing these activities in non-covered areas (Jack et al., 2008). Therefore, the design of PES requires careful analysis of all the incentives it may generate and their interaction with the local context. For example, areas with limited market integration (and transportation infrastructure) are more likely to experience increases in local food prices following the withdrawal of land from agricultural activities.

Evidence indicates that assigning the dual objective of increasing the provision of ecosystem services and reducing poverty to PSE programs can be ineffective when the resources at greatest risk of degradation are not owned by the poorest households (Jack et al., 2008). In their study on Mexico's PSAH, Alix-Garcia et al. (2015) found that this program had a significant impact on reducing deforestation (between 40% and 50% less than what would have occurred without the program). The authors point out that the crops' effectiveness could have been even greater if the program had focused on high-risk areas, but doing so would have resulted in lower participation among the population living below the poverty line.

In summary, PSE can be an effective tool for preserving ecosystems and biodiversity and addressing climate change. To achieve this, appropriate design and implementation based on the local context are indispensable. Desirable characteristics of a PSE program include targeting high-risk areas, differentiating payments based on the level of degradation risk and ecosystem type, and enforceable conditionality (Maldonado and Moreno-Sánchez, 2023). Additionally, the allocation of multiple objectives can diminish its effectiveness. The management of a PSE program requires an agency with institutional capacity and credibility among providers and beneficiaries. PSE programs are long-term schemes, so if they depend on public resources, they are vulnerable to changes in political priorities and macroeconomic conditions (Alpízar, Madrigal et al., 2020). The establishment of trusts that guarantee participating providers a stream of payments for a specified period is one alternative in this regard. Furthermore, for PSE to function, well-defined land property rights are necessary (Blackman et al., 2014), a condition that, as discussed, is not always met in Latin America and the Caribbean.

PSEs are a vehicle with the potential to channel international cooperation for the conservation and regeneration of ecosystems. This is exemplified by the mechanism of Reducing Emissions from Deforestation and Forest Degradation (REDD+), under the UNFCCC. REDD+ operates a results-based payment scheme that allocates funds to developing countries to promote the conservation and sustainable management of forests and to increase the carbon stocks of forest.

Development banks can play an important role in the expansion and consolidation of PSE programs. For example, by working with governments and local organizations, engaging international donors, providing financial support and capacity development, and participating in the design and implementation of these programs (Alpízar, Madrigal et al., 2020).

### Environmental certifications and industry agreements

Eco-certifications can be a valuable tool for providing reliable and accessible information to consumers regarding the environmental impact of specific goods or products. This policy is based on the assumption that there is a growing demand for goods and services that have been produced using sustainable practices. However, obtaining trustworthy information about the environmental impact of various goods and services can be costly for consumers. The difficulty that consumers face to distinguish between environmentally friendly products and those that are not decreases the incentives for producers to adopt sustainable practices. Eco-certification operates through a body that establishes a set of mandatory standards for a good or service to display a label that informs consumers about its environmental impact (Maldonado and Moreno-Sánchez, 2023).

Eco-certifications are an increasingly widespread practice. Currently, there are more than 456 ecolabels in 199 countries and 25 industry sectors (Big Room, 2023) administered by governmental and non-governmental organizations, industry associations, and private companies, covering a diversity of agricultural products. Latin America and the Caribbean is a leading region in the adoption of eco-certifications, primarily for the production of bananas, coffee, and cocoa (Blackman et al., 2014). In terms of organizations, the Forest Stewardship Council, a prominent certifier of sustainable forest management, has been operating in the region since 1993 and certifies 12.8 million hectares of forests, with approximately half of them located in Brazil. Another scheme in this field is the Program for Endorsement of Forest Certification (PEFC), aimed at small landowners in Argentina, Brazil, Chile, and Uruguay (Maldonado and Moreno-Sánchez, 2023).

For eco-certification programs to be effective, they require: 1) the establishment of rigorous environmental standards that are effectively enforced, and 2) the additional price that consumers are willing to pay for an eco-certified product or service must be sufficient to cover at least the additional costs that producers incur to meet the required environmental practices and the operating costs of the program (Blackman et al., 2014). The evidence regarding the impact of eco-certification on ecosystem preservation and biodiversity is still limited and requires further development to better understand the conditions under which these programs can be most effective (Blackman and Rivera, 2011; Rico-Straffon et al., 2023).

**Latin America and the Caribbean is a leading region in the adoption of eco-certifications, although there is a need to better understand how to increase their impact on the preservation of ecosystems and biodiversity**

Industry agreements or interventions in the supply chain are another alternative to encourage producers to adopt sustainable practices. In this case, companies within a sector agree not to purchase products or services from suppliers that fail to meet environmental safeguards. The most relevant example is the “Soy Moratorium” agreement in Brazil, driven by the major soybean buyers in the country (organized by the Brazilian Vegetable Oil Industries Association and the National Association of Cereal Exporters), agricultural producers, and NGO Greenpeace (Ferreira, 2023). The agreement obliges participating traders to purchase only soybean produced on lands that have not been deforested after July 2016, a condition that was initially monitored through aerial inspections and later with remote sensors. Existing evidence suggests that the moratorium was successful in contributing to the reduction of deforestation in the Amazon by reducing the returns that producers obtained from expanding agricultural frontiers (Nepstad et al., 2014; Rudorff et al., 2011). Conversely, a similar initiative to avoid the purchase of cattle raised in deforested areas in Brazil had limited success due to the challenge of establishing effective traceability mechanisms for the origin of the animals (Ferreira, 2023).

The significance of environmental certifications can increase in light of international initiatives, primarily promoted by the European Union, that aim to impose trade barriers on products originating from deforested areas (see Chapter 4).

### Subsidy reform

As seen in the subsection "Enabling factors" the existence of direct and indirect subsidies to the agricultural and fishing sectors can contribute to ecosystem and biodiversity degradation. Subsidies can have a detrimental effect on ecosystems when they contribute to higher profits for producers engaged in activities such as land use conversion, overexploitation of natural resources, and the adoption of unsustainable practices. Examples include subsidies for biofuels, fishing fleet operations, irrigation, and fertilizers. The first ones increase the demand for agricultural land use, the second ones favor the overexploitation of marine and freshwater species, the third ones contribute to the overexploitation of water resources, and the fourth ones facilitate the excessive use of inputs that harm ecosystems (Blackman et al., 2014; Maldonado and Moreno-Sánchez, 2023).

In addition to their negative effects on ecosystems, these subsidies can consume significant fiscal resources. In Latin America and the Caribbean, subsidies to the agricultural sector have been increasing since the 1980s, reaching USD 5.4 billion in 2008 (Blackman et al., 2014). These include direct transfers and subsidies for irrigation, fertilizers, and other production inputs. Similarly, countries in the region provided around USD 2.25 billion in subsidies to the fishing sector in 2018, mainly for fuels and through tax exemptions (Cisneros-Montemayor et al., 2016; Sumaila et al., 2019).

Under Target 3 of the Aichi Biodiversity Targets, countries in the region committed to eliminating or reforming incentives and subsidies harmful to biodiversity by 2020. This commitment was reaffirmed under Target 18 of the Global Biodiversity Framework for 2030, but progress in this regard has been limited (CBD Secretariat, 2022).

### Non-discriminatory subsidies to the agricultural and fishing sectors can contribute to the overexploitation and ecosystem and biodiversity degradation

The agenda for reforming subsidies with negative effects on biodiversity faces political opposition from the groups that receive them. In terms of design, the challenge is to prevent subsidies from creating perverse incentives that lead to the overuse of natural resources or inputs that harm ecosystems and biodiversity. One alternative to elimination is decoupling subsidies from incentives, which means replacing production-conditional subsidies and input subsidies with direct transfers that do not depend on production or consumption decisions. This is a particularly attractive option when subsidies aim to combat poverty. In the case of subsidies that seek to address market failures that limit the development of industries (e.g., due to incomplete credit markets), an alternative is to condition access to subsidies on compliance with environmental safeguards.

In this regard, in 2008, the Central Bank of Brazil conditioned the granting of subsidized credits to agricultural producers located in the Amazon biome on compliance with non-deforestation requirements stipulated in the country's Forest Code. This conditionality led to a reduction in deforestation of about 60% compared to what would have occurred in the absence of the policy, which targeted municipalities where cattle ranching is the main economic activity (Assunção, McMillan, et al., 2019).

A frequently used argument by countries to avoid subsidy elimination is that taking this measure would put their industry at a disadvantage with respect to other countries where subsidies do exist, which underlines the importance of international coordination in this regard (see more information on this topic in Chapter 4).