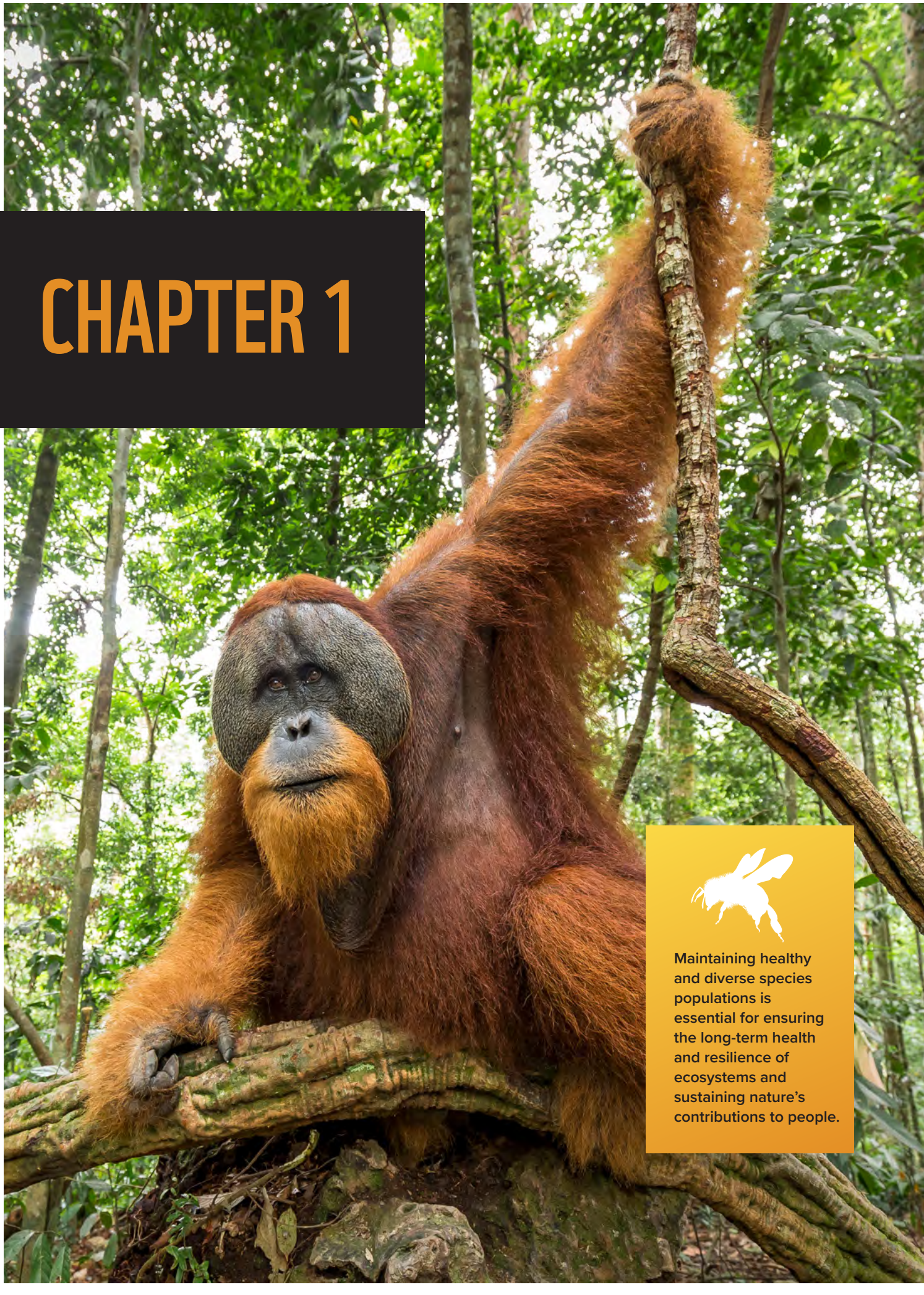
CHAPTER 1



Maintaining healthy and diverse species populations is essential for ensuring the long-term health and resilience of ecosystems and sustaining nature's contributions to people.

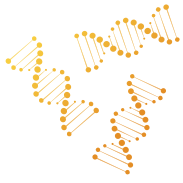
Measuring nature's decline

What is biodiversity and why is it important?

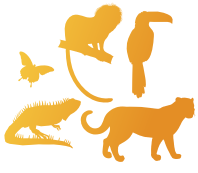
Biodiversity is the heartbeat of our living planet. The astonishing array of life on Earth is the greatest marvel in the known universe. It also, directly and indirectly, sustains human life – from the food we eat to the fuel and medicines we need for survival, from clean air and water to a stable climate. Our economies, our societies, our civilizations: biodiversity underpins them all.

Biodiversity is defined as "the variability among living organisms including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part"[1]. That variability includes differences within species and ecosystems, as outlined in Box 1.1. Biodiversity, in all its forms, has direct and indirect effects on our quality of life[2] – sometimes referred to as "nature's contributions to people".

Box 1.1 The diversity of biodiversity



- **Genetic diversity:** The variation of genetic information within a population, species or ecosystem including differences in genes, alleles and genetic traits. Genetic diversity is essential for evolution in response to change.



- **Species diversity:** The variation and abundance of different species within a specific area, encompassing both the number of species (species richness) and their relative abundance (species evenness). High species diversity indicates a healthy and resilient ecosystem capable of supporting various ecological functions and services. Loss of species diversity can disrupt ecosystem functioning and reduce overall ecosystem stability.

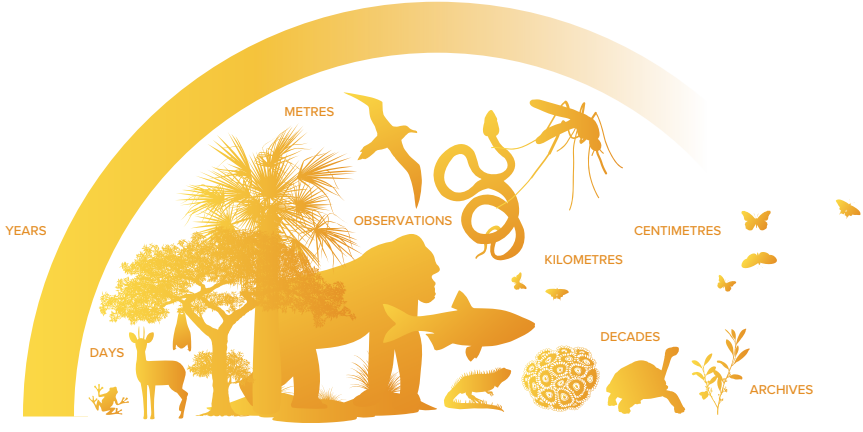
- **Population diversity:** The variation and distribution of individuals within a species across different geographic regions or habitats including differences in traits, behaviours and genetic composition among populations of the same species. Population diversity reflects the adaptability of a species to change and influences its ability to persist over time.

- **Ecosystem diversity:** The variation of ecosystems within a region including different types of terrestrial, marine and aquatic ecosystems, such as forests, grasslands, wetlands, coral reefs, rivers and lakes. Ecosystem diversity reflects the structural and functional complexity of landscapes and supports a wide range of species and ecological processes, enhancing overall ecosystem resilience and productivity.

- **Ecosystem functional diversity:** The variation in ecological processes, such as nutrient cycling, primary production and decomposition, and species' ecological roles, functions and contributions to these processes. High functional diversity enhances ecosystem resilience.

"Nature" is a more holistic term than biodiversity that has a multitude of meanings for different peoples and cultures around the globe, though the two terms are often used interchangeably. People perceive, experience and interact with nature in ways that shape their understanding of how it contributes to their quality of life. As the world's cultures are diverse, so too is the range of values related to nature.

Nature is increasingly managed and harvested to keep pace with rising global demands for food, water, energy, timber, fibre and more. This accelerating appropriation of nature is fraying the fabric of life on which we all depend[3]. Today's policies and practices often disregard the multiple values of nature in favour of a narrow set of market values focused on short-term economic growth. Non-market values associated with nature's contributions to people – like regulating the climate, providing water, healthy soils, or the joy and wonder that nature inspires – are overlooked and undermined. For our own sakes, we need to embrace the diverse values of nature and ensure these are reflected in public policy, private sector investments and individual actions at local, national and global scales[4].



How do we measure nature?

Measuring how and why nature is changing is critical if we are to effectively address the threats to our vital natural systems. Various biodiversity indicators have been developed to measure different facets of nature and to assess its status and change over time. While no single measure is sufficient to capture all aspects of nature, when used in combination these indicators can tell us how nature is changing globally and locally. They can also help us understand where and how to focus conservation efforts and to project how nature may change under different scenarios. This helps identify future risks and evaluate the best solutions to maintain the benefits of nature while minimizing negative impacts. All indicators that track the state of nature at a global scale, whether monitored by natural or social scientists, show a decline[3]. These losses have consequences for society, many of which are only now beginning to manifest themselves in the form of local and regional tipping points (see Chapter 2).

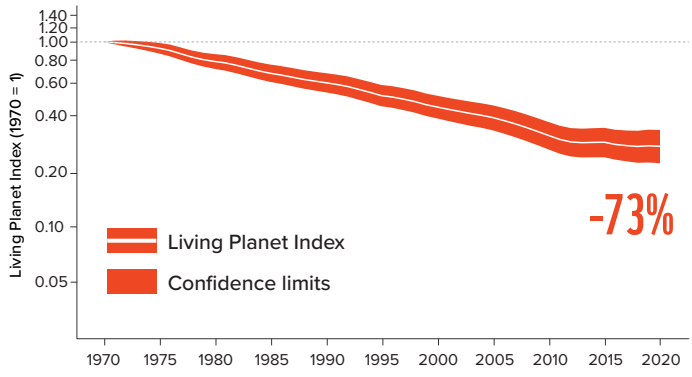
Nature narratives: Using indicators to understand change over different timescales

Some indicators reflect short-term trends, such as those measuring abundance and extinction risk, and may be used to predict near-term change. Others provide a longer view of past and future change, for example biodiversity intactness (or state of integrity) and the rate of extinctions[5,6]. Both types are important. Taken together, they provide vital information about the health and resilience of nature.

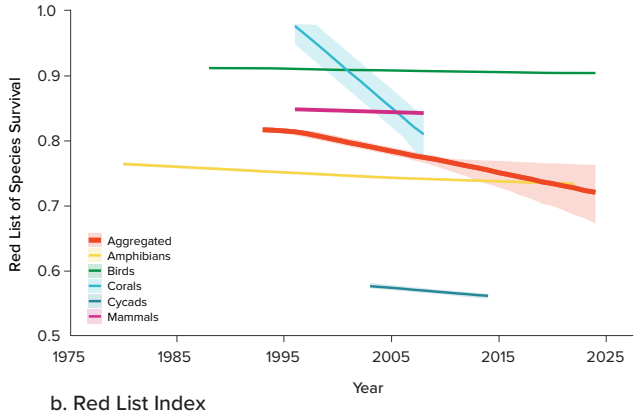
The Living Planet Index (LPI) helps us to see recent changes in nature from 1970 to the present by tracking the size of animal populations and how they are changing (Figure 1.1a). The LPI is an early warning indicator of increasing extinction risk and the potential loss of ecosystem function and resilience. It affords us an opportunity to intervene in time to reverse negative trends, recover species populations, and keep ecosystems functioning and resilient.

The Red List Index, an indicator of trends in the extinction risk of groups of species, also provides information about the changing state of nature. The IUCN Red List of Threatened Species assesses the likelihood that a species will go extinct across all its populations, based on past, current and projected future trends[7]. The index shows whether species in a group are becoming more (or less) at risk of extinction: the lower the value, the greater the risk that species in that group will go extinct. Extinction risk is increasing in all monitored species groups according to the Red List Index (Figure 1.1b): in other words, without significant intervention, it is highly probable that species will be lost. Species facing extinction may not be able to perform their usual role within their ecosystem, which can reduce the functioning and resilience of an ecosystem overall.

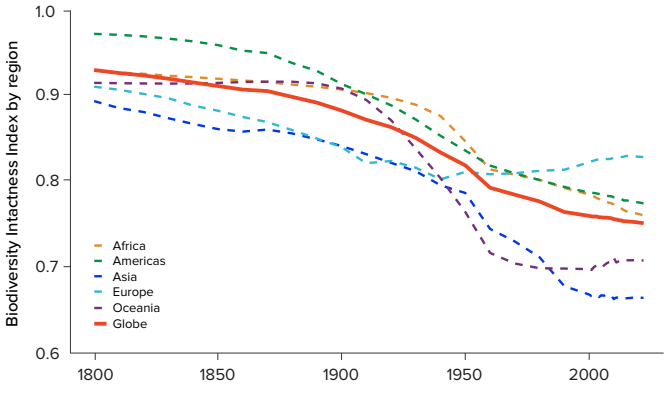
The Biodiversity Intactness Index is a long-term indicator that measures how much original biodiversity remains within terrestrial communities in a given region. The trajectory since 1800 shows the effect of agricultural expansion and intensification on terrestrial biodiversity around the world: although intactness has declined across all regions, Asia has shown the steepest and largest decline over the past century (Figure 1.1c). For another longer-term perspective (centuries), the outcome of continued declines in species abundance and population size can be seen in the number and rate of extinctions. With data reaching back as far as the 1500s, scientists have estimated that the extinction rate (the rate at which we lose species forever) is at least tens to hundreds of times higher than it would be in the absence of human activity (Figure 1.1d).



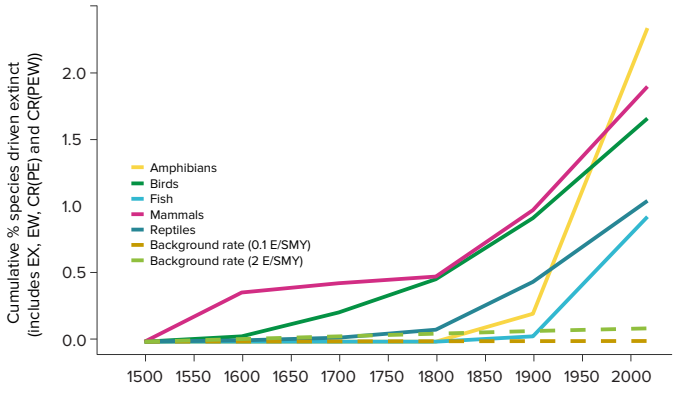
a. Global Living Planet Index



b. Red List Index



c. Biodiversity Intactness Index



d. Rate of extinctions

Figure 1.1 Indicators show changes in biodiversity across different timescales. Each tells a different story, but all are part of a larger narrative of nature's decline. The Living Planet Index (a) tracks animal populations and allows us to interpret recent changes in nature[8]. The Red List Index (b) shows extinction risk for groups of species and incorporates recent trends and future threats[7]. The Biodiversity Intactness Index (c) highlights long-term trends and shows how intact terrestrial biodiversity is compared to the year 1800[9]. The number of extinctions (d) shows a longer-term trend from 1500 and tracks the cumulative number of species known to have gone extinct[1].

Nature narratives: from populations to ecosystem function

Species populations contribute to the functioning of ecosystems and provide vital contributions to people through their interactions with each other and their environment (Box 1.2). Maintaining healthy and diverse populations is essential for ensuring the long-term health and resilience of ecosystems and sustaining nature's contributions to people.

Box 1.2 Ecosystem function, ecosystem services and nature's contributions to people

Ecosystem function refers to the processes that occur within an ecosystem. These processes are essential for the ecosystem's stability, productivity and resilience. Ecosystem functions include nutrient cycling, primary production, decomposition, water purification, pollination and climate regulation. Ecosystem services are the benefits that humans derive from ecosystems such as food, clean water and a stable climate. Ecosystem services result from ecosystem functions, but they are evaluated as services based on their value to humans rather than their importance to the ecosystem itself. Expanding on ecosystem services, the concept of nature's contributions to people, or NCP, emerged from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[3] as a way to recognize and value the full range of interactions between people and nature, particularly the broader cultural, social and spiritual connections.

A study in the Atlantic Forest in Brazil of more than 2,000 tree species and more than 800 animal species provides an example[10]. Researchers found that when the forest loses populations of large fruit-eating animals (tapirs, toucans, tamarins, deer) due to hunting and illegal trade, it loses the seed dispersal function for large-seeded trees that these animals provide, and the composition of tropical tree species changes (Figure 1.2). Since the large-seeded trees are predominantly larger hardwood trees which store more carbon, the forest loses carbon storage capacity as it becomes dominated by smaller, softwood trees. This phenomenon has the potential to cause carbon storage losses of 2–12% across forests in Africa, Latin America and Asia[11], reducing tropical forest carbon storage capacity in the face of climate change.

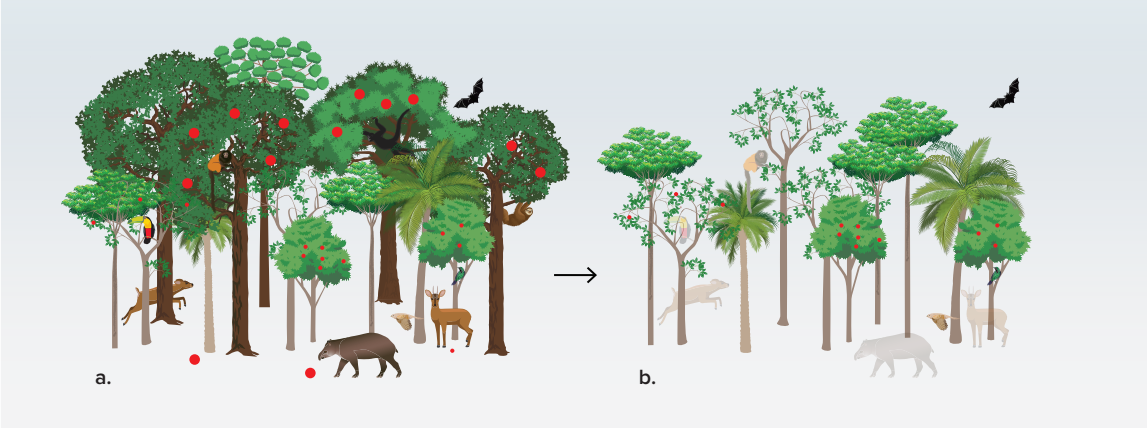


Figure 1.2 Losses of populations of large fruit-eating animals by hunting in tropical forests lead to a decline in forest carbon storage, exacerbating climate change. (a) When large animals such as the Brazilian tapir, the green-billed toucan, the black-faced lion tamarin, and the grey brocket deer that eat large fruit (indicated by red dots) are hunted and their populations decline, the large fruits and seeds that they eat are no longer dispersed throughout the forest. Since the trees in this forest that store more carbon also have larger fruits and seeds, the forest loses the carbon-dense, hardwood tree species over time (indicated in dark brown trunks). (b) The resulting forest is dominated by carbon-poor, softwood tree species with small fruits and seeds that store less carbon (indicated in light brown trunks). Figure adapted from Bello et al. 2015[10].

Similarly, the herbivorous parrotfish plays a crucial role in controlling coral-damaging algal growth on Mesoamerican coral reefs by grazing on the algae[12,13] (Figure 1.3). When parrotfish are overfished and their populations decline, algae can overgrow and outcompete corals for space, light and nutrients. This can lead not only to a decline in coral health and diversity, as corals struggle to survive in the presence of excessive algae, but also the decline of many other species that rely on the coral reef for habitat and food. Removing the parrotfish reduces the productivity of the coral, decreases the number and size of populations of other species it can support, and weakens its ability to withstand additional stressors such as climate change, pollution and disease. This leaves it more vulnerable to further degradation and potential collapse.

a.

b.

Figure 1.3 The stoplight parrotfish (a) grazes on the algae and microbes on the surface of the corals, allowing the corals access to space, light and nutrients to grow. This results in a healthy coral reef that supports many coral, fish and invertebrate populations. (b) When the parrotfish is overfished and its population declines, the coral reef becomes overrun by algal growth, the corals die, and the fish and invertebrate populations that depend on the corals decline.

The global Living Planet Index 2024

The Living Planet Index (LPI) tracks changes in the relative abundance of wild vertebrate species populations over time[14]. Relative abundance refers to the rate at which wildlife populations are changing over time, regardless of the size of that population. Populations may contain many individuals or very few: by measuring change in relative abundance, the LPI tracks the average trend rather than increases or declines in the total number of individual animals[15].

Despite 30 years of policy interventions to stop nature loss, the declines shown in previous reports continue. The global LPI 2024 shows a decrease of 73% between 1970 and 2020 (range: -67% to -78%), representing an average annual decline of 2.6% (Figure 1.4). This means that over 50 years, the size of monitored wildlife populations in the LPI has reduced, on average, by almost three quarters. Almost 35,000 population trends and 5,495 species are included in the LPI. These data are collected from monitoring sites around the world and include populations that are increasing, decreasing or stable over time. Not all the populations in the LPI are declining: many show positive or stable trends and this often varies according to the type of species and region of the world in which it lives[16].

By monitoring changes in the size of animal populations over time, the LPI helps us understand the health of ecosystems. Trends in the abundance of populations, or how many individual animals there are of each species at a particular location, show how well ecosystems are functioning[17]. Stable populations in the long term provide resilience against disturbances like disease and extreme weather events. A decline in populations, as shown in the global LPI, decreases resilience and threatens the stability of the ecosystem[18,19].

This global index is an average of the three indices that measure changes in ecosystems on land, in our rivers and lakes, and at sea (Figure 1.4). These results indicate that nature is declining on average across all systems: terrestrial (69% decline (range: -55% to -79%), representing an average annual decline of 2.3%), freshwater (85% decline (range: -77% to -90%), representing an average annual decline of 3.8%) and marine (56% decline (range: -43% to -66%), representing an average annual decline of 1.6%).

This means that over 50 years, the size of monitored wildlife populations has reduced, on average, by almost three quarters.

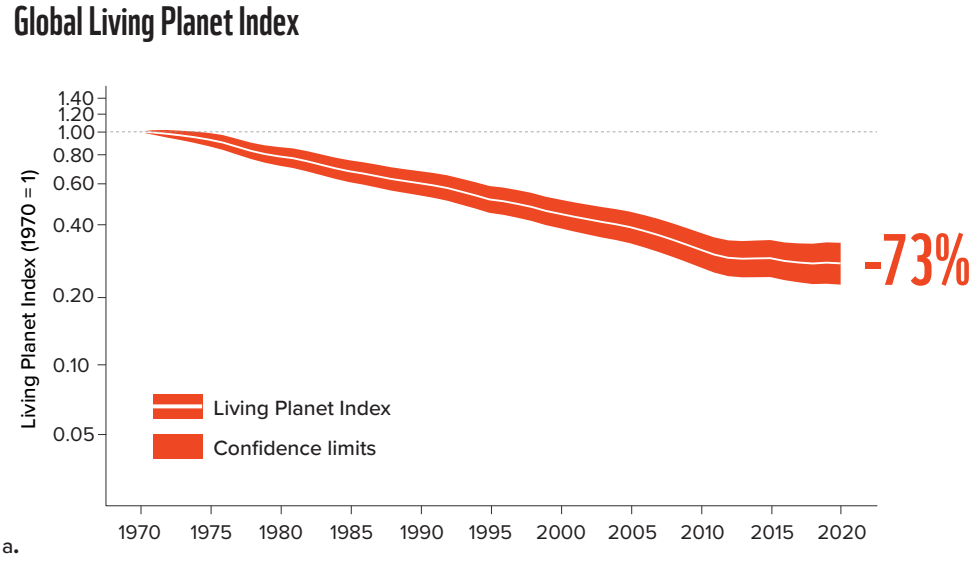
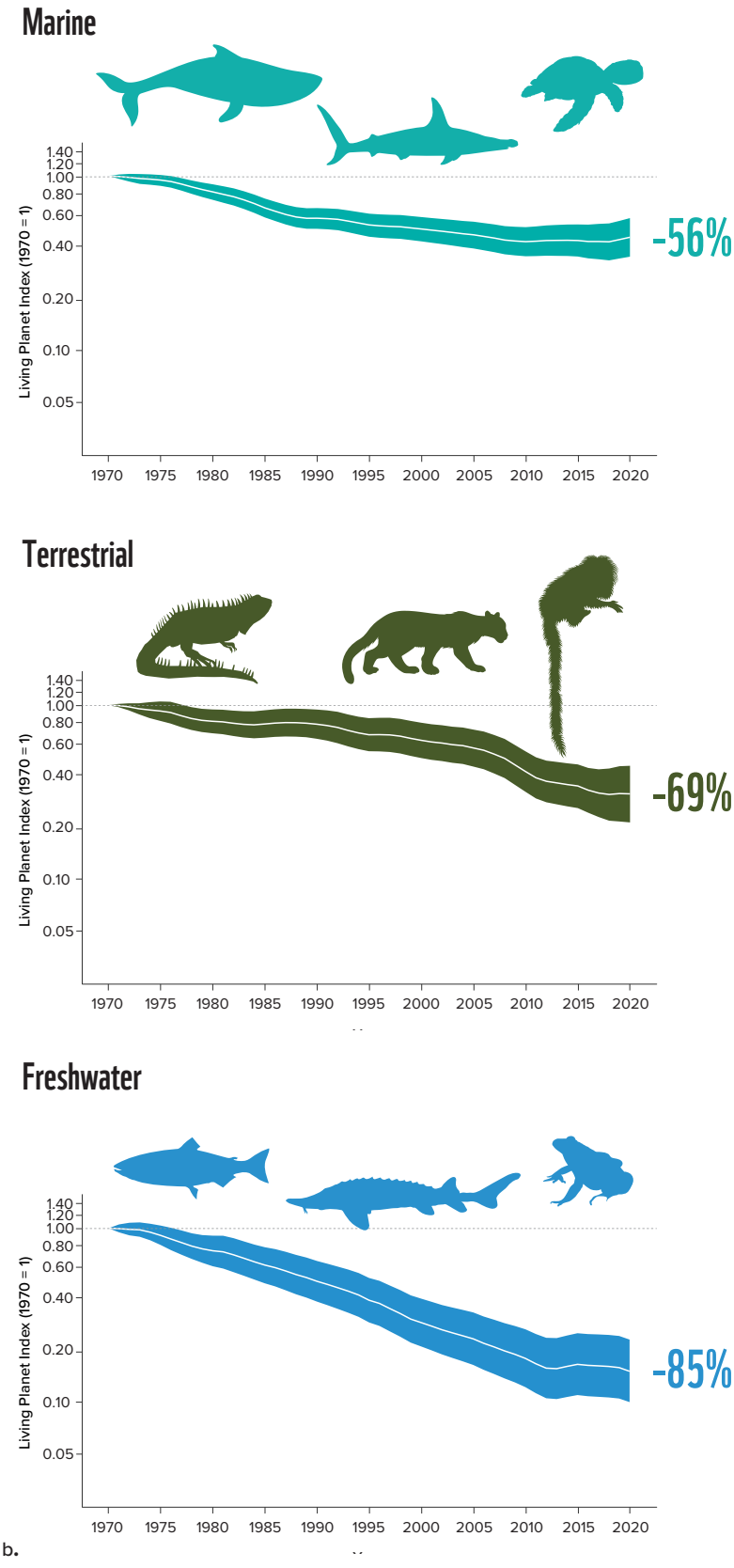


Figure 1.4 (a) The global Living Planet Index from 1970 to 2020 based on 34,836 monitored populations of 5,495 vertebrate species. The white line represents the index value, and the shaded areas represent the statistical uncertainty surrounding the value.

The marine index has declined the least out of the three systems over the 50-year period. This index is dominated by species of fish, many of which are managed to control the level of fishing pressure. Some managed fish stocks have shown recoveries in recent years, and others have shown stability which is reflected in the lower overall decline in the marine LPI[20,21]. However, other marine fish such as sharks and rays continue to show critical levels of decline[22,23].

The terrestrial index includes species from habitats such as forests, deserts and grasslands, and shows a trend of similar magnitude to the global index (69% decline).

The strongest decline is shown in the freshwater index and reflects the increasing pressure placed on freshwater habitats and species (85% decline). In particular, freshwater fish are often threatened by alterations to their habitat which can block essential migration routes. For example, the updated LPI for migratory freshwater fish shows a decline of 81% between 1970 and 2020[16].

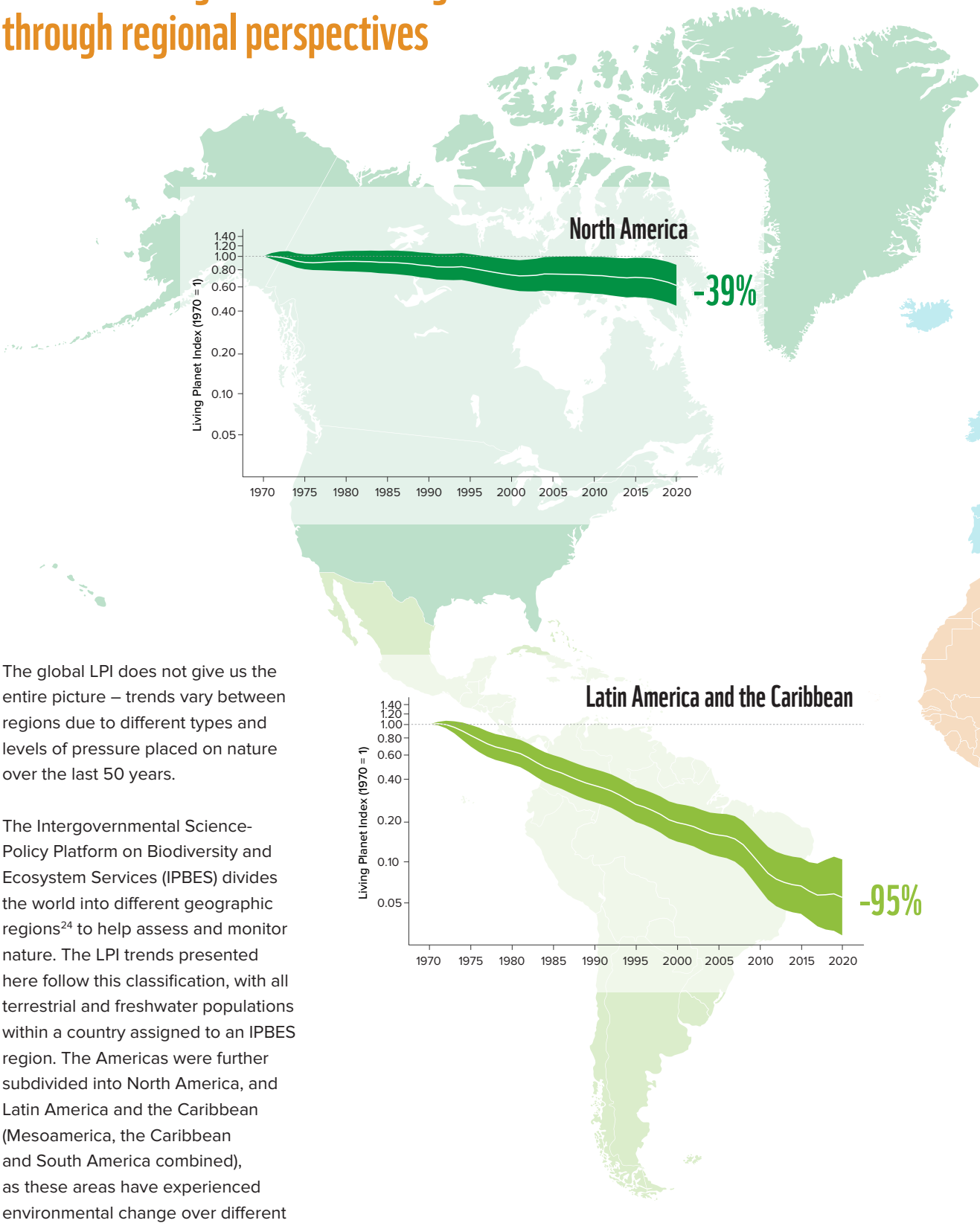


b.

Figure 1.4 (b) The Living Planet Index by ecosystem type from 1970 to 2020 based on 16,909 populations of 1,816 marine species, 11,318 populations of 2,519 terrestrial species, 6,609 populations of 1,472 freshwater species.

We use a logarithmic scale for the y-axis in the Living Planet Index charts which helps us show changes in the index more accurately[16].

Understanding drivers of change to nature through regional perspectives



The global LPI does not give us the entire picture – trends vary between regions due to different types and levels of pressure placed on nature over the last 50 years.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) divides the world into different geographic regions[24] to help assess and monitor nature. The LPI trends presented here follow this classification, with all terrestrial and freshwater populations within a country assigned to an IPBES region. The Americas were further subdivided into North America, and Latin America and the Caribbean (Mesoamerica, the Caribbean and South America combined), as these areas have experienced environmental change over different time periods. Trends for each species group are weighted according to how many species are found in each IPBES region (Figure 1.5).

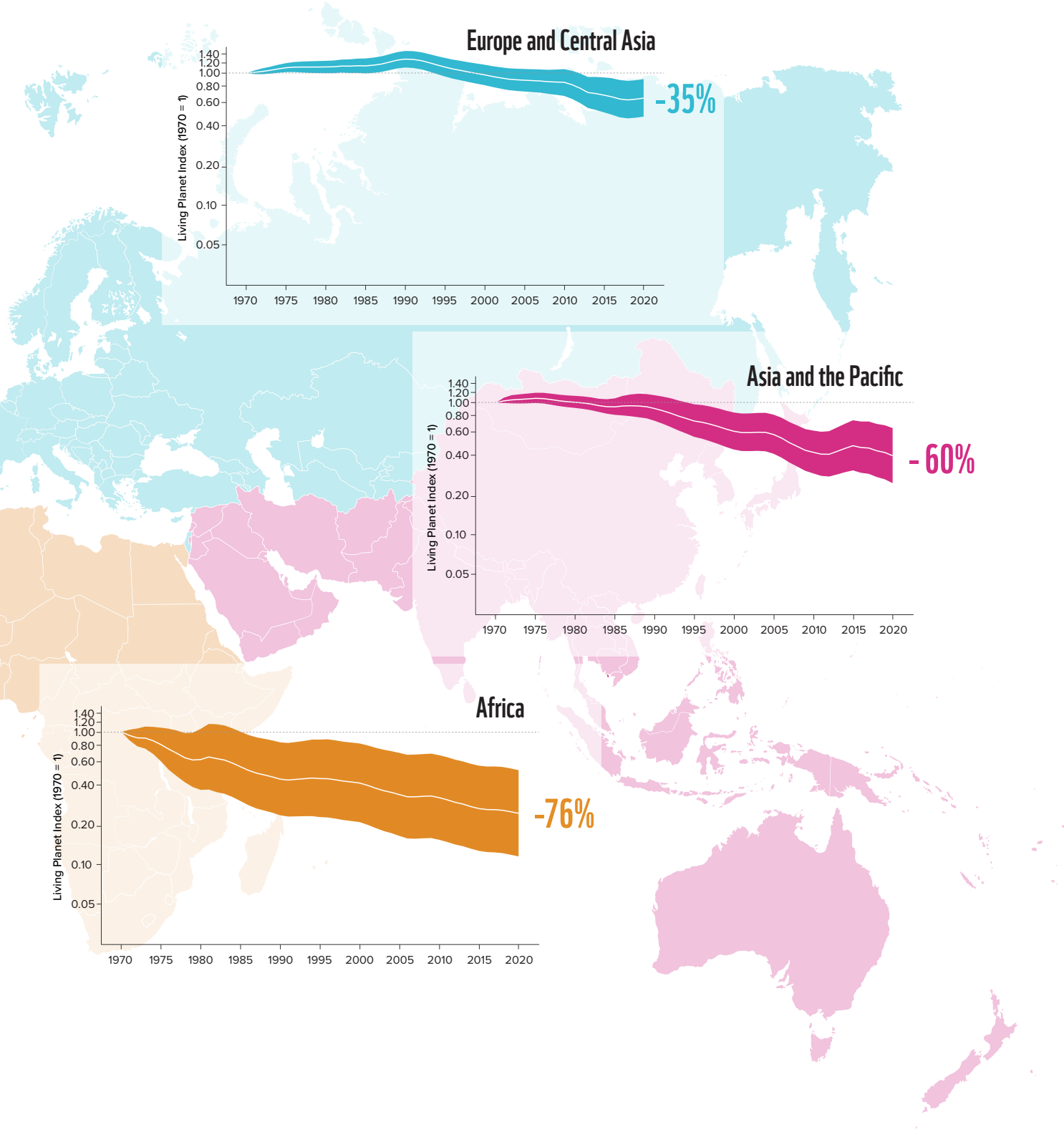


Figure 1.5 The Living Planet Index by IPBES regions for combined terrestrial and freshwater populations from 1970 to 2020, based on 2,449 populations and 935 vertebrate species in North America, 3,936 populations and 1,362 species in Latin America and the Caribbean, 4,615 populations and 619 species in Europe and Central Asia, 4,622 populations and 768 species in Asia and the Pacific and 2,304 monitored populations of 552 species in Africa. White lines represent the index value and the shaded areas represent the statistical uncertainty surrounding the value[8].

The indices for the IPBES regions show how trends in nature vary across regions, and help us understand the different drivers of change in populations (Figure 1.5). In the LPI, information on current threats is available for over 5,000 populations. This is summarized to show how frequently each threat type has been recorded for different species groups in each IPBES region (Box 1.3, Figure 1.6). Habitat degradation and loss is the most reported threat to vertebrate populations in each IPBES region, followed by overexploitation, invasive species and disease[16]. Climate change is more frequently cited for populations in Latin America and the Caribbean, and pollution is most reported in North America and Asia and the Pacific[16].

The steepest declines are seen in Latin America and the Caribbean, Africa and Asia and the Pacific (Figure 1.5). But pressures on nature in one region can be driven by forces from other regions through trade and resource extraction. For example, Europe and Central Asia has the highest ecological footprint of consumption (a measure of the natural resources and services a country consumes) of any IPBES region while also exceeding its biocapacity (the land available to produce these resources) by the largest amount; the region is therefore reliant on importing resources from nature-rich regions[25].

Box 1.3 Dominant drivers of change

- **Habitat loss/degradation:** This refers to the modification of the environment where a species lives, by either complete removal, fragmentation or reduction in quality of key habitat. Common changes in use are caused by unsustainable agriculture, logging, transportation, residential or commercial development, energy production and mining. For freshwater habitats, fragmentation of rivers and streams and abstraction of water are common threats. Marine habitats can be impacted by both activity on land, for example coastal development, and at sea, such as bottom trawling or dredging which can damage seabed habitats.

- **Overexploitation:** There are both direct and indirect forms of overexploitation. Direct overexploitation refers to unsustainable hunting and poaching or harvesting, whether for subsistence or for trade. Indirect overexploitation occurs when non-target species are killed unintentionally, for example as bykatch in fisheries.

- **Climate change:** As temperatures change, some species will need to adapt by shifting their range to track a suitable climate. The effects of climate change on species are often indirect. Changes in temperatures can confound signals that trigger seasonal events such as migration and reproduction, causing these events to happen at the wrong time. For example, misaligning reproduction and the period of greater food availability in a specific habitat.

- **Pollution:** Pollution can directly affect a species by making the environment unsuitable for its survival. This is what happens, for example, in the case of an oil spill. It can also affect a species indirectly, by affecting food availability or reproductive performance, thus reducing population numbers over time.

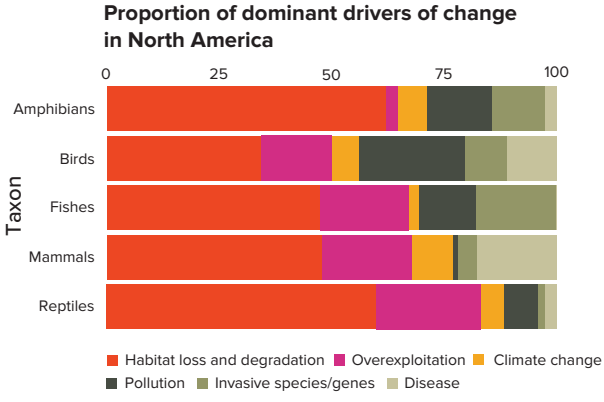
- **Invasive species/genes:** Invasive species can compete with native species for space, food and other resources; they can also be predators of native species.

- **Disease:** Species that expand their range or are introduced into a new area can transport diseases that were not previously present in the environment. Humans also transport new diseases from one area of the globe to another. Other threats such as climate change and habitat degradation can increase a species' susceptibility to disease.

- **North America** shows a 39% decline between 1970 and 2020 (range: -14% to -57%), which is equivalent to 1% decline per year (Figure 1.5). In North America, large-scale impacts on nature were already apparent before 1970, which partly explains why there is less of a negative trend than in other regions: many populations have stabilized but starting from a lower baseline[26]. There have also been some conservation successes for individual species, including certain mammals such as bighorn sheep[27], and groups such as raptors (birds of prey), many of which have recovered from historical declines[28]. The Americas are home to seven of the 17 megadiverse countries – countries that are especially rich in nature and endemic species (those found nowhere else)[29]. The differing trends for North America and for Latin America and the Caribbean reflect the difference in environmental conditions at the start of the indices in 1970.

- **Latin America and the Caribbean** show the fastest rate of decline of any region since 1970. The index declined by 95% between 1970 (range: -90% to -97%) and 2020, equivalent to 5.7% change per year (Figure 1.5). The conversion of grasslands, forests and wetlands, the overexploitation of species, climate change and the introduction of alien species have contributed to this precipitous decline[29]. In this region, climate change is more frequently reported as a threat to populations in the LPI[16]. For example, it has been suggested that climate change exacerbated the effects of a devastating fungus affecting some amphibian species in South America[30] and, in relatively undisturbed habitats, climate change may be driving the decline in some Amazonian forest birds[31]. As species populations decline, the Amazon basin, a critical system within this region, is facing the risk of reaching a tipping point (see Chapter 2).

Trends vary between regions due to different types and levels of pressure placed on nature over the last 50 years.



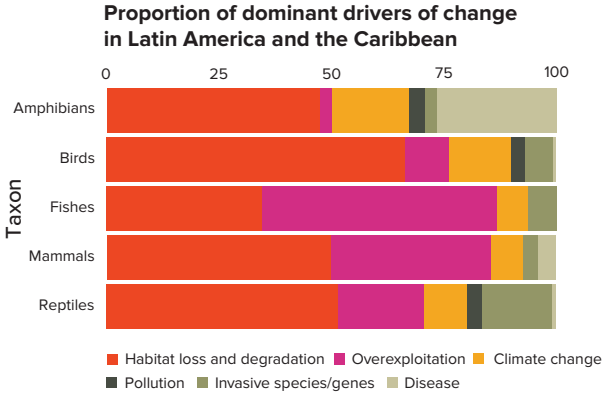
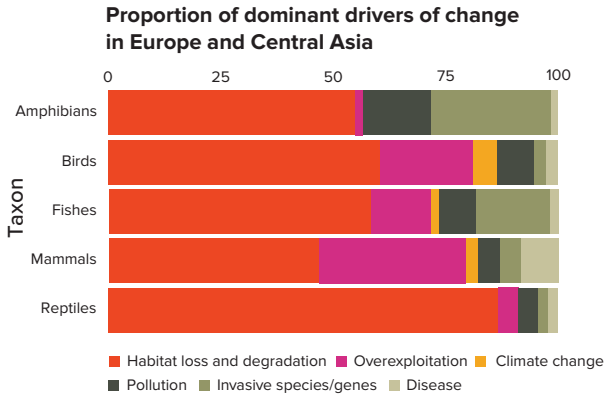


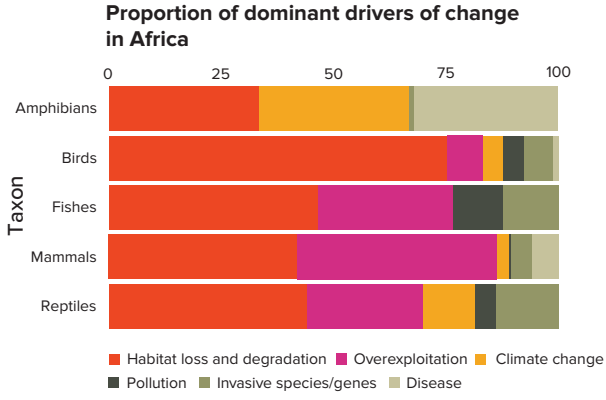
Figure 1.6 The proportion of the decline in vertebrate populations (amphibians, birds, fish, mammals and reptiles) due to the dominant drivers of change (habitat loss/degradation, overexploitation, invasive species/genes, pollution, disease, and climate change) by IPBES region[8].

- **Europe and Central Asia** is another region where nature was already in a poorer state in 1970, particularly in Western Europe. This is reflected in the index, which shows a relatively slow rate of decline at 35% (range: -10% to -53%), equivalent to 0.9% per year (Figure 1.5). Europe has also witnessed the comeback of a number of wildlife species such as the European bison and Dalmatian pelican[14], because of species reintroductions, legal protection and other conservation actions. However, average trends in freshwater fish, reptiles and amphibians are mostly negative, and these species groups are at a greater risk of extinction in Europe[32,33].

- **Africa** is unique as a region, home to significant numbers of large mammals[34] and incredibly rich in biodiversity. The LPI for Africa shows a decline of 76% (range: -49% to -89%), equivalent to 2.8% per year (Figure 1.5). Africa's biodiversity provides essential resources for many rural populations, as well as for the rest of Africa and globally[34]. Overexploitation is more commonly reported as a threat to LPI populations in Africa than other regions[16], and trends in populations that are used by people show greater declines than in other regions[35,36]. This highlights the urgent need to protect these vital resources.

- **Asia and the Pacific** comprises many varied land regions and habitats including small and large islands, home to many endemic species and unique ecosystems[37]. The LPI for this region declined by 60% (range: -76% to -36%), equivalent to 1.8% per year (Figure 1.5). The threat of invasive species and disease is frequently reported for populations in Asia and the Pacific; invasive species threaten many island endemics. For example, on the Pacific island of Guam, the accidentally introduced brown tree snake has put many bird species under threat of both local and global extinction[38]. Two species endemic to Guam – bridled white-eye and Guam reed-warbler – are already globally extinct[38]. The Mariana swiftlet, which is native to Guam and the Northern Mariana Islands, is threatened with extinction due to its small population size and threat from the invasive brown tree snake[39,40].





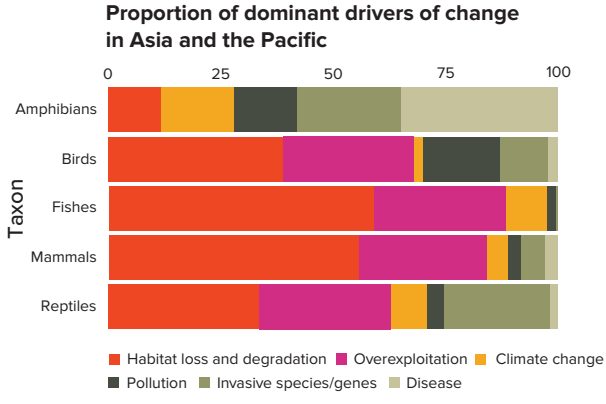


Figure 1.6 (continued) The proportion of the decline in vertebrate populations (amphibians, birds, fish, mammals and reptiles) due to the dominant drivers of change (habitat loss/degradation, overexploitation, invasive species/genes, pollution, disease, andclimate change) by IPBES region[8].