The Biodiversity Crisis Is a Business Crisis

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BCG

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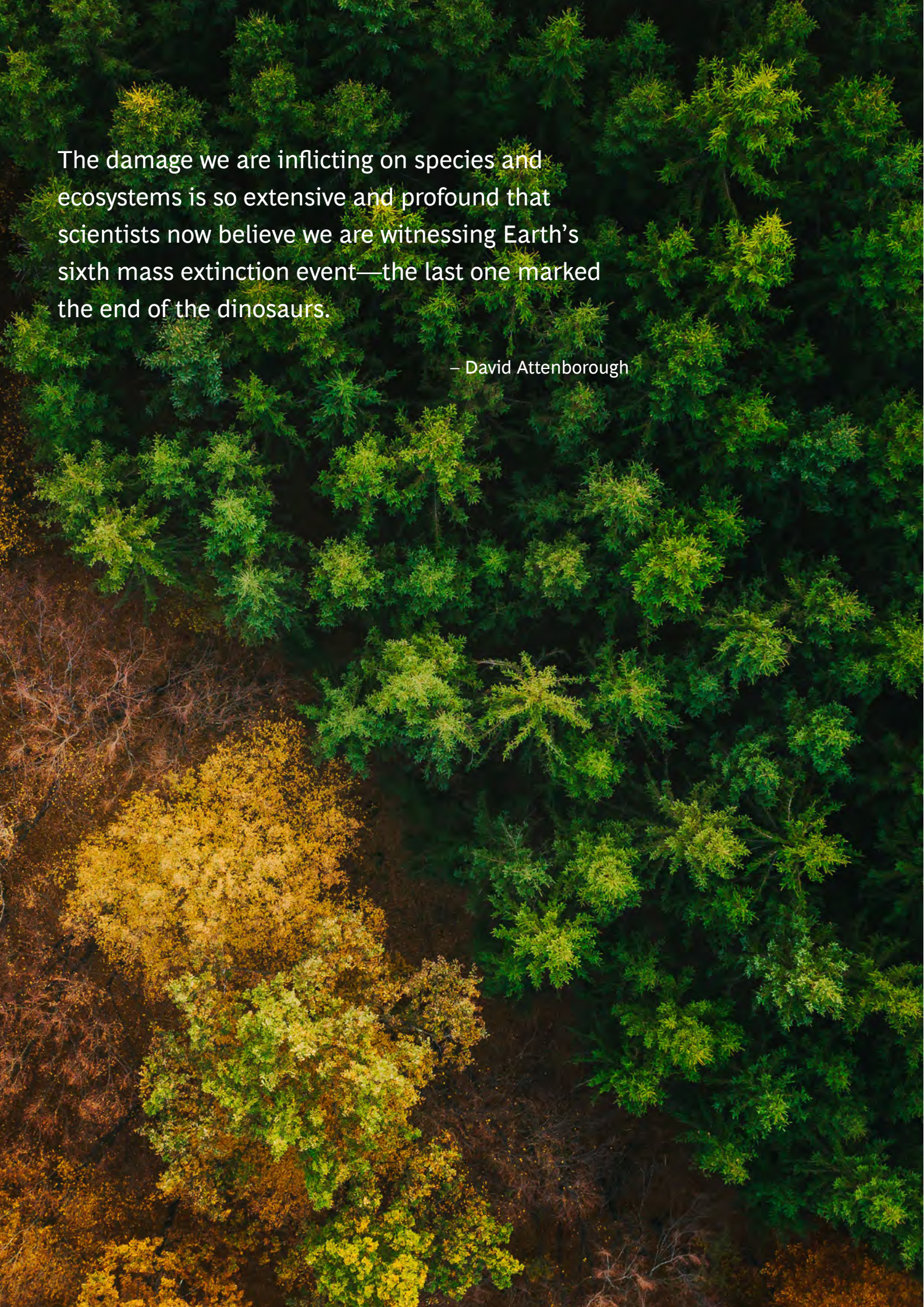


The damage we are inflicting on species and ecosystems is so extensive and profound that scientists now believe we are witnessing Earth's sixth mass extinction event—the last one marked the end of the dinosaurs.

– David Attenborough

Introduction

The Biodiversity Challenge

Two facts about biodiversity are not up for debate. The first is widely known, the second less so.

Fact number one: biodiversity—the level of diversity in the natural world, at the ecosystem, species, and genetic levels—is being destroyed at an alarming rate. Fully one-fifth of the world's countries are now at risk of ecosystem collapse, according to an analysis by Swiss Re Institute. And as crucial ecosystems such as tropical forests and coral reefs near tipping points, that dynamic could set off a chain reaction that would fundamentally change our environment, threatening the livelihood of billions of people and making the planet less hospitable to humanity. The World Economic Forum (WEF) has identified biodiversity loss as the fourth-greatest global risk—after infectious disease, climate action failure, and weapons of mass destruction. Ultimately, the two trends are mutually reinforcing: climate change accelerates ecosystem degradation, which in turn increases the release of carbon into the atmosphere and reduces carbon sequestration.

Fact number two: biodiversity loss has massive implications for business. Although climate change has been at the top of the global business agenda for years, the threat that the biodiversity crisis poses is only now coming into full view. More than half of the world's GDP depends heavily on functioning natural ecosystems, according to the WEF. As those ecosystems decline, business faces significant risks. Food and fashion makers may face higher costs for raw material inputs due to degraded soils and the loss of natural pollinators. Flooding, soil erosion, or pandemics will impact nearly every corner of the corporate world. And any company that contributes to the biodiversity crisis may lose the support of consumers and investors alike. But the crisis also creates real opportunity. Companies that act to support biodiversity can develop powerful new offerings and business models, improve the attractiveness of existing offerings, and lower operating costs.

BCG set out to study the biodiversity crisis, understand the business role, and determine how companies should respond. Among our findings:

- Biodiversity creates significant economic value in the form of such ecosystem services as food provisioning, carbon storage, and water and air filtration. Ecosystem services alone are worth more than $150 trillion annually—about twice the world's GDP—according to academic research and BCG analysis.

- Five primary pressures—land-use and sea-use change, direct overexploitation of natural resources, climate change, pollution, and the spread of invasive species—are causing steep biodiversity loss. Already, the decline in ecosystem functionality is costing the global economy more than $5 trillion a year in the form of lost natural services.

- Many business activities—in particular, activities related to resource extraction and cultivation—contribute to the pressures driving biodiversity loss. Currently more than 90% of man-made pressure on biodiversity is attributable to the operations of four major value chains: food, energy, infrastructure, and fashion. BCG has identified 15 objectives that, if broadly achieved around the world, would prevent much of the harm to biodiversity that these value chains currently cause.

Companies that want to address this impact in order to reduce the risks to their business and seize new opportunities must develop an action plan. First, they must determine the necessary scope of action on biodiversity, based on the company's impact on vital ecosystems along its value chains. Second, they should align on science-based targets and establish systems to measure and report progress toward those targets. Third, they must build the right foundation for success, including a trained and incentivized staff and strong partnerships. Fourth, they need to take the right actions, given the specifics of their business. These actions will include some combination of reducing their biodiversity footprint; transforming their value chains through innovative, biodiversity-positive products, services, and business models; and advancing biodiversity beyond their own footprint to promote resilient, healthy ecosystems, particularly in areas critical to the company's operations.

Preserving biodiversity is a complex undertaking. Many local and global pressures are at work, and those pressures impact various ecosystems differently. Companies need to understand those dynamics and develop strategies tailored to address challenges at the local ecosystem level. The good news: many companies will find that they have already done some of the work required to make their business biodiversity positive (or nature positive)—for example, through efforts to monitor the practices of their suppliers or to track scope 3 greenhouse gas (GHG) emissions. Ultimately, companies that lead this change can reap major economic benefits. Failure to act, on the other hand, will carry a steep price for both business and the planet.

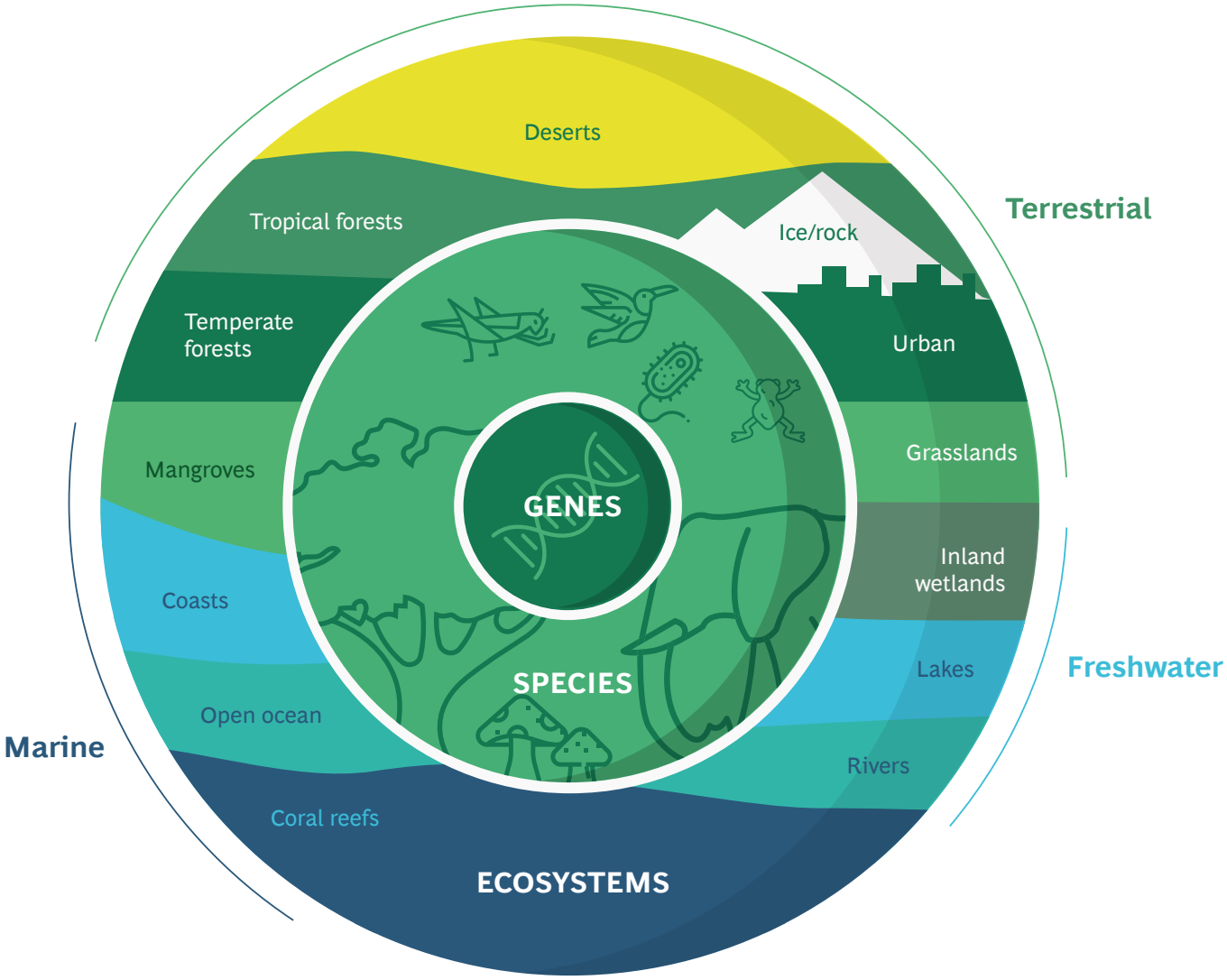
The Value of Biodiversity—and Its Precipitous Decline

The phenomenon of biodiversity is complex and often difficult to grasp. It is also vital to sustaining both human livelihoods and the global economy. Unfortunately, biodiversity is declining at a dangerous clip today, due to a host of man-made pressures.

Understanding Biodiversity

If you ask people what ***biodiversity*** means, the first thing that many of them will mention is the protection of iconic animal species such as tigers or polar bears. But the true parameters of the term are much broader. (See Exhibit 1.) Ultimately, biodiversity reflects the diversity of life on Earth—and thus the health and resilience of nature—at three levels:

Exhibit 1 - Biodiversity Is Defined by the Variability in Ecosystems, Species, and Genes

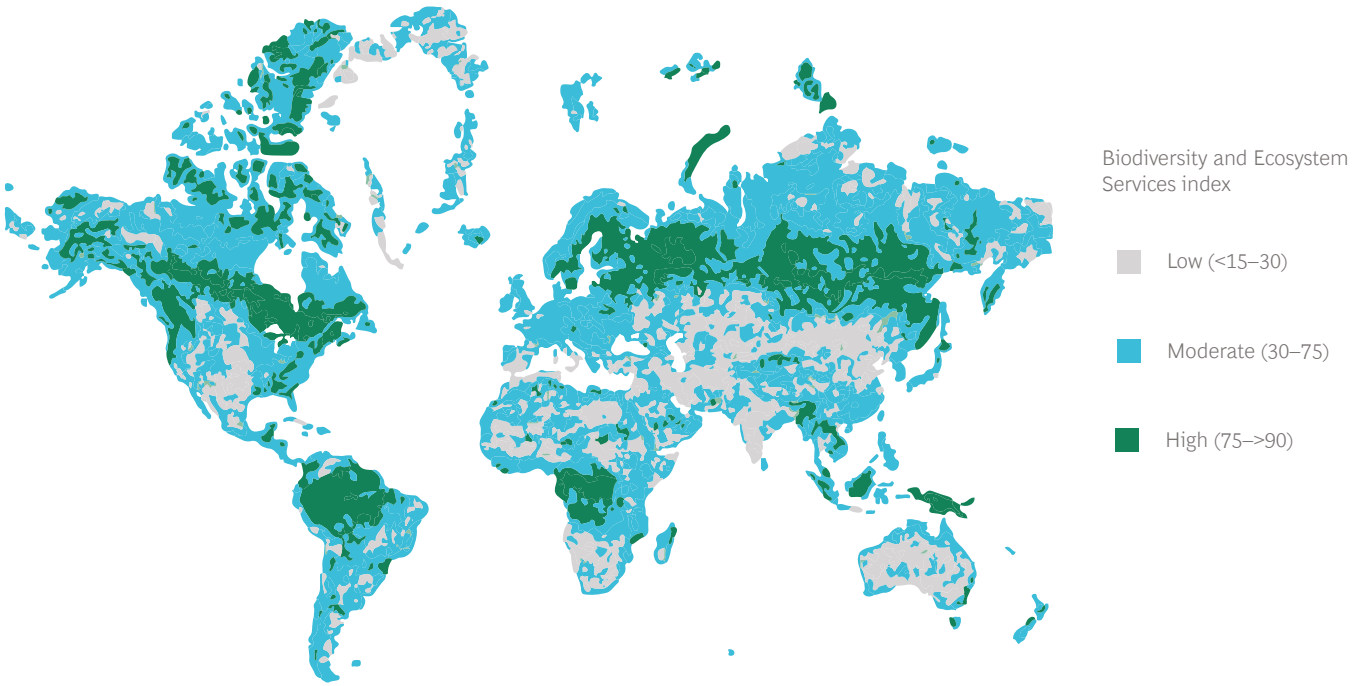


Sources: IPBES, "Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services" (2019); International Union for Conservation of Nature, Red List of Threatened Species (2019 update); Group on Earth Observations Biodiversity Observation Network; BCG analysis.

- **Ecosystems.** Diversity at the level of entire ecosystems, such as wetlands, grasslands, or forests, is a function of the size of the intact ecosystem area, the magnitude of its biomass, and its ability to provide ecosystem services like water regulation or air purification.
- **Species.** The variation in species, including plants, animals, and microorganisms involves both richness (number of species) and abundance (population for each species) within each ecosystem, and the distribution of species across ecosystems.
- **Genes.** Genetic variability is essential to species' ability to adapt to environmental changes and their resilience to external threats, such as diseases

These building blocks of biodiversity spread across three types of ecosystems, or biomes. Marine ecosystems, which cover as much as 70.5% of the Earth's surface, include the open ocean, coastlines and salt marshes, mangroves, and coral reefs. Terrestrial ecosystems cover 29% of the planet's surface and include tropical and boreal forests, grasslands, deserts, ice and rock areas, and developed areas such as croplands, farmlands, and urban areas. Freshwater ecosystems make up just 0.5% of the Earth's surface, but they

Exhibit 2 - Some Regions of the World Hold Particularly Critical Ecosystems



Source: Swiss Re Institute (analysis based on multiple data sources).

include such delicate, biodiversity-rich ecosystems as inland wetlands, lakes, and rivers. Each of the three biomes contains many key biodiversity areas—sites whose health contributes significantly to overall global biodiversity. Among these are certain highly diverse wetlands, grass plains, and forests, as well as many biodiversity-rich marine sites such as coral reefs. In general, assessing an ecosystem in isolation omits various crucial factors affecting biodiversity; connectivity across ecosystems to enable migration, mating, and feeding grounds is critical.

Although there is no single, widely accepted indicator of biodiversity, metrics to assess the diversity and health of global ecosystems are available. For example, Swiss Re Institute has developed the Biodiversity and Ecosystem Services Index to track the relative state of terrestrial biodiversity in regions around the world. (See Exhibit 2.) This assessment indicates that areas such as tropical rainforests in South America, Central Africa, and Indonesia and boreal forests and tundra in the northern hemisphere host particularly vibrant ecosystems. The high-index areas on this map may be particularly vital, but every country on Earth hosts a plethora of ecosystems with unique local biodiversity that is essential to its inhabitants and to the functioning of natural cycles.

The Economic Value of Biodiversity

The delicate balance and interplay between ecosystems, species, and genes produce services that are vital to the functioning of society and the modern economy and, therefore, create sizable economic value. Over half of global GDP—around $43 trillion—depends on high-functioning biodiversity, according to the WEF. For example, more than 75% of global food crops, including fruits, vegetables, almonds, and coffee, rely on pollinators such as bees, and some 70% of antibiotics and drugs used to fight cancer are natural substances or synthetic products inspired by nature. Moreover, natural ecosystems sequester about one-third of global GHG emissions annually, instead of allowing them to be released into the atmosphere, according to the UN's Intergovernmental Panel on Climate Change (IPCC).

But while the public, including the business community, has a general sense of the importance of some ecosystem services, such as pollination and carbon sequestration, the overall variety and value of these services remain underappreciated. For example, access to food crops and other natural products ultimately depends on foundational services such as soil formation and water regulation. Failure to recognize the full significance of such functions leads to insufficient efforts to preserve biodiversity and ecosystem services in general.

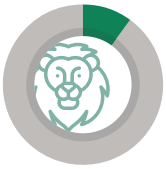
Quantifying the value of ecosystem services can raise awareness of the importance of biodiversity and create momentum for change. Ecosystem services fall into four primary categories: regulating, cultural, habitat, and provisioning. On the basis of research from The Economics of Ecosystems and Biodiversity (TEEB) initiative, we estimate that the combined annual value of these four ecosystem services is more than $150 trillion, almost twice global GDP.[1] (See the appendix for more details.) This value is split across the categories as follows:

~60%

Regulating. Natural ecosystems provide multiple services that are essential to environmental stability. Among them: climate regulation (through carbon sequestration), water storage and filtration, air purification, recycling of nutrients, prevention of soil erosion, and control of biological disturbances such as diseases. One way to approximate the economic value of these services is by calculating the opportunity costs that would be incurred without them. For example, we computed the climate regulation value by multiplying the carbon sequestration rate of different ecosystems by a carbon price of $50 to $120 per ton—a range that reflects the full cost of CO_2 emissions to society at different social discount rates. We estimate that regulating services, in total, account for 60% of total ecosystem services value.

~20%

Cultural. Natural ecosystems serve spiritual, heritage, educational, and recreational functions. We excluded spiritual, cultural heritage, and educational benefits from our calculations, however, given the difficulty of assigning objective dollar figures to those functions. Even so, the value from travel, tourism, and other forms of recreation alone accounts for around 20% of the total.



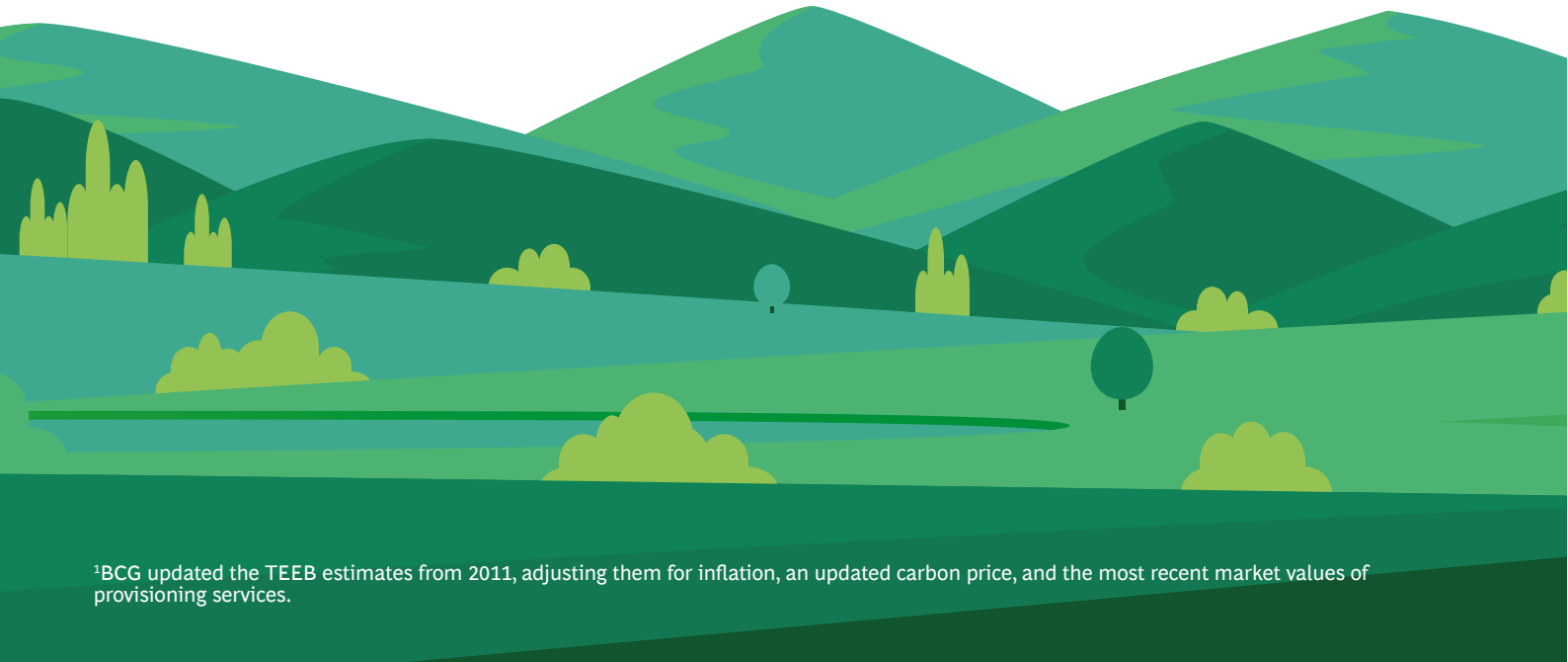
>10%

Habitat. Ecosystems provide two forms of habitat services. First, they offer space for plant, animal, and microorganism species to live, migrate, and procreate. Second, they support the formation of fertile soil, which is vital for the survival of plants and other organisms, and for food production. Cumulatively, these habitat services account for more than 10% of total ecosystem services value.

5%–10%

Provisioning. This category captures the value of products such as food, timber, and medicinal inputs created within ecosystems. We based our estimates of provisioning services on market values for those products, but excluded the portion of that value created through man-made activities such as cultivation and raw material conversion. Our research indicates that provisioning comprises roughly 7% of total ecosystem service value.

Total ecosystem service value **>$150 trillion**



[1]BCG updated the TEEB estimates from 2011, adjusting them for inflation, an updated carbon price, and the most recent market values of provisioning services.

Biodiversity value is not static, and its true worth probably far exceeds the value of ecosystem services calculated here. First, it is difficult to estimate the intrinsic value of habitat and cultural services with precision. Second, benefits due to the interplay between ecosystems—which enables the migration of species and stabilizes natural cycles such as precipitation or wind currents—cannot yet be reliably modeled.

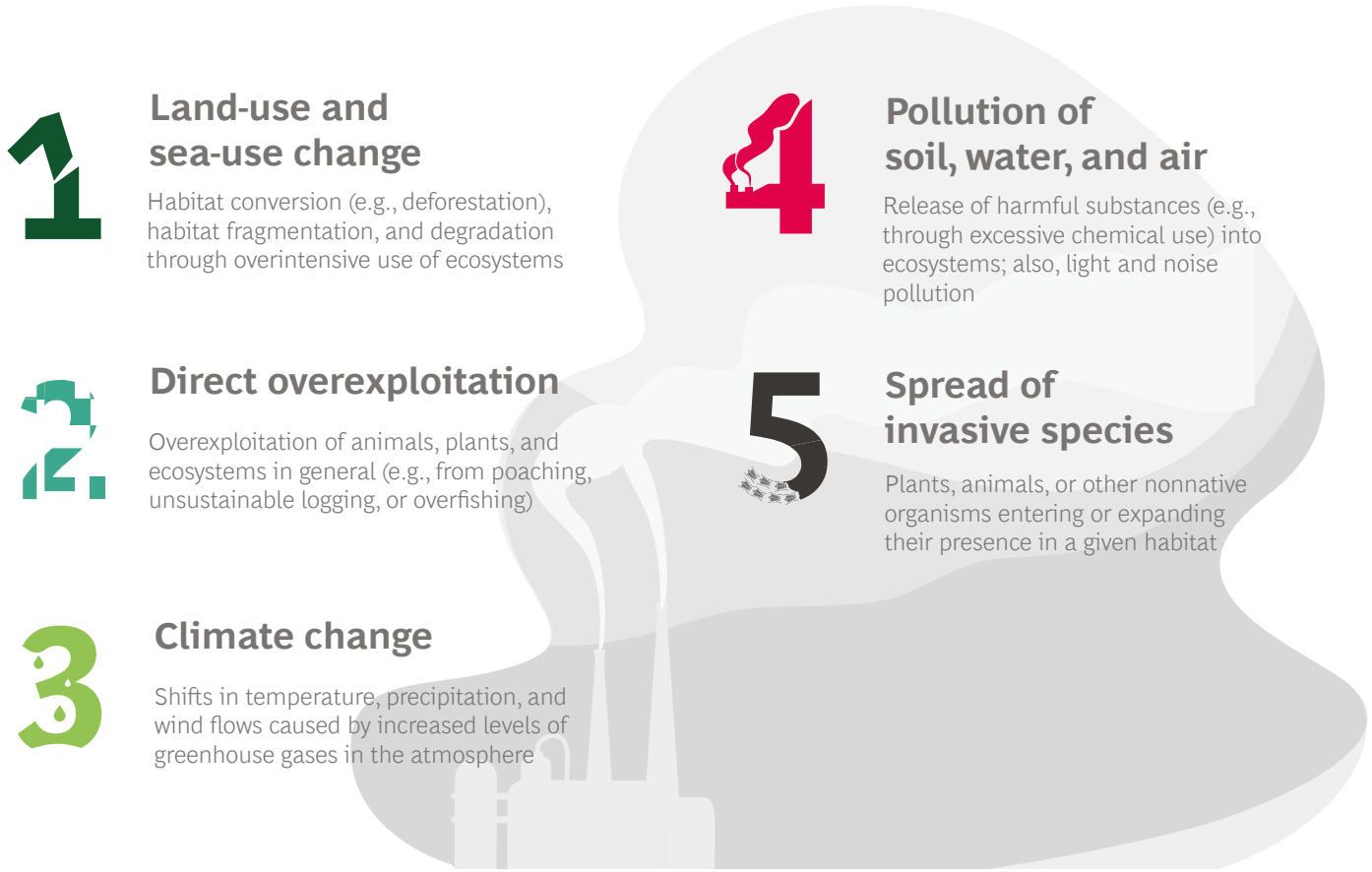
The Drivers and Dangers of Biodiversity Loss

Two basic conditions are essential to ensure healthy biodiversity around the world. First, some ecosystems, especially key biodiversity areas, must be protected from significant human impact, an approach known as *land sparing*. This imperative is reflected in targets outlined by the scientific community that aim for protection of 30% of land and sea areas by 2030 and 50% by 2050. Second, given the world's reliance on natural resources, people must combine land-sparing approaches with land-use practices in nonprotected areas that address the needs of local and migrating species—for example, through sustainable forest management or locally adapted limits on fishing. Unfortunately, in the face of global population growth, rising urbanization, and increasing per-capita consumption, efforts to preserve global biodiversity have taken a back seat to meeting the increased demand for land and natural resources. As a result, global biodiversity is on a steady downward trajectory.

According to scientists, the Earth is now in a high-risk zone in terms of biosphere health, and we are experiencing the planet's sixth mass extinction of species—66 million years after the extinction of the dinosaurs. Some 66% of marine ecosystems and 75% of terrestrial ecosystems have been severely altered by human activity, and 85% of wetlands have been lost. Between 1970 and 2016, population sizes of mammals, birds, amphibians, reptiles, and fish decreased by an average 68%, according to the World Wide Fund for Nature (WWF) Living Planet Index, and by a staggering 94% in the tropical regions of the Americas. Livestock now accounts for more than 60% of the biomass of all mammals, with wild mammals comprising just 4% and humans the remaining 36%. At the same time, there is a significant lack of cultivated biodiversity: just four crop species provide two-thirds of human caloric intake.

According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), five pressures are primarily responsible for driving biodiversity loss (see Exhibit 3):

Exhibit 3 - Five Major Factors Drive Biodiversity Loss



Source: IPBES, "Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services" (2019).

- **Land-Use and Sea-Use Change.** This category of pressure is the single largest factor driving biodiversity loss. Land-use change involves the conversion, degradation, and modification of ecosystems. Conversion may occur to make space for the cultivation of crops—including crops used for food, clothing, animal feed, or biofuels—or to exploit resources and expand infrastructure. Humans have already converted about 60% of global habitable land. And scientists consider about 30% of all soils worldwide to be degraded already as a result of severe erosion, mostly due to agricultural activities on converted lands. Meanwhile, infrastructure drives the modification of habitats and natural systems, too. For example, roadways, railroads, and pipelines can cut through and disrupt critical habitats or wildlife corridors, and dams can alter the flow of natural waterways. At sea, coastal development and offshore aquaculture drive most change.

- **Direct Overexploitation.** Direct overexploitation—the extraction of more animals, plants, and other resources than can be naturally restored—is the second-largest factor in biodiversity loss. In the past ten years, human activities have consistently exceeded the Earth's regenerative capacity by more than 50%. Overexploitation often results from insufficient regulation and takes such forms as overlogging, overgrazing, excessive extraction of freshwater, overfishing, and the hunting and poaching of endangered species. Overexploitation of ocean resources, for example, is rapidly degrading a primary global food source that BCG estimates is worth about $24 trillion—nearly equal to the market cap of the S&P 500.

- **Climate Change.** Climate change is likely to become a more prominent driver of biodiversity loss in the coming decades. It indirectly catalyzes and accelerates other biodiversity pressures by spurring ecosystem and species decline, evident today in rising ocean acidification and desertification, melting ice landscapes, and catastrophic events such as floods, wildfires, or droughts. That degradation in turn releases carbon stored in these ecosystems, contributing to further climate change. This is a dangerous feedback loop because many biomes, such as forests and peatlands, store carbon on a massive scale. In contrast to the other pressures, the effect of climate change on biodiversity is not regionally confined, as emissions accumulate on a global scale. (See the sidebar "Why Biodiversity Loss Is a More Complex Challenge Than Climate Change.")

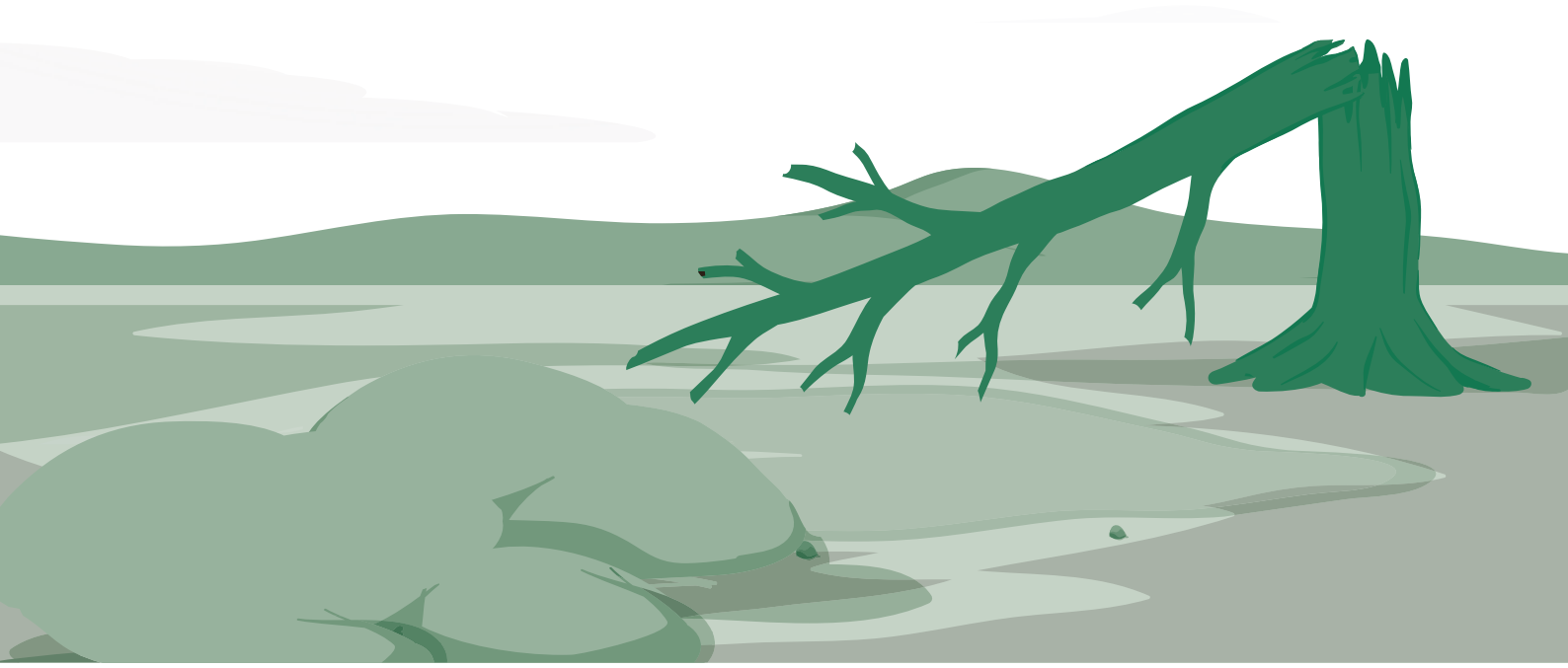
- **Pollution of Soil, Water, and Air.** Pollution can significantly harm ecosystem functionality by changing the composition of soils, waterways, and the ocean in terms of nutrients, acidity, and oxygen levels. For example, runoff from soils and waters containing high levels of phosphates and nitrogen can cause eutrophication, resulting in excessive plant and algae growth, reduced oxygen levels, and ultimately aquatic death zones, as seen in the Baltic Sea. Common pollutants include microplastics, heavy metals, endocrine disruptors, crop protection agents, fertilizing nutrients, and chemical components of pharmaceuticals, cosmetics, and household cleaning products. Among the sources of soil and water pollution are agricultural chemicals, oil spills, toxic runoff from resource extraction sites, wastewater from industrial sites, and inappropriately discarded consumer products. Plastic waste is a particular and well-known challenge. Some 11 million metric tons of plastic flow into the ocean each year, waste that is linked to around 1 million marine animal deaths annually. Meanwhile, industrial air pollution in the form of gases such as nitrous oxide, fine particles, and organic pollutants harms biodiversity through effects such as acid rain and temperature increases due to depletion of the ozone layer.

- **Spread of Invasive Species.** Invasive alien species are nonnative plants, animals, or other organisms that enter alternative habitats. Such species may arrive through global trade or tourism or proliferate as a result of crop cultivation. Infiltrating areas in large numbers, they may destabilize entire ecosystems by competing for food, trampling soils, or crossbreeding with local species. Today, according to IPBES, roughly 20% of the Earth's land and water are at risk from alien species.

These five pressures have had a significant impact in recent decades: TEEB estimates and BCG analysis indicate that total annual ecosystem service value has declined by at least $5 trillion since the late 1990s. That means each year the world economy forfeits ecosystem services worth about 6% of global GDP, an amount roughly equivalent to the total market value of agriculture, forestry, and fishery output in 2019.

Beyond those direct losses, the continued decline of biodiversity threatens to systematically erode the fundamental requirements of society for food, water, and clean air, as well as a stable climate and protection from external shocks.

$5 trillion



A Major Economic Hit

The decline of ecosystem functionality is costing the global economy more than $5 trillion a year in terms of lost natural services

Why Biodiversity Loss Is a More Complex Challenge Than Climate Change

Climate change and biodiversity loss are closely linked—but the two issues differ in three significant ways.

First, biodiversity exhibits more complex dynamics of cause and effect. The relationship between GHG emissions and climate change is essentially linear: more emissions produce more warming. But the relationships between the various pressures described in this report and biodiversity loss are nonlinear, each having a complex impact on interrelated biological systems at both a local level and a global level. As a result, tracking a business's biodiversity footprint requires more sophisticated measurement systems than those needed to track its carbon footprint.

Second, biodiversity is difficult to substitute. It is possible to offset emissions in one location through measures such as afforestation in a different locale, but habitats are locally distinct. Sometimes it is possible to mitigate a negative impact in one location by restoring habitat in or relocating species to a location nearby. More typically, however, it is impossible to offset the loss of key species in a certain ecosystem through efforts in a different ecosystem.

Third, actions to address biodiversity loss require a locally differentiated approach. Because no two ecosystems are alike, global target setting, alignment, and best practice sharing are inherently complex. In contrast, emission reduction can be achieved through similar approaches, regardless of where those efforts occur.

These threats are likely to be evident on multiple fronts. First, the resilience of crops and livestock decreases as their genetic variability does. Research has found that up to 80% of the primary breeds of cattle used for milk production in the US may have descended from only two male chromosomes. And global coffee production is based on just two species: Robusta and Arabica. If lethal diseases strike such genetically uniform key species, major disruptions to food chains could follow. In response to this danger, organizations have undertaken efforts to preserve genetic diversity—for example, the Svalbard Global Seed Vault, which stores backup seed samples from around the world. Second, even if we succeed in preserving genetic diversity, our food system depends on the health of natural habitats. Diverse crops still depend on the presence of fertile soil and abundant pollinators. Third, the loss of regulating services will exacerbate the impact of climate-related natural disasters such as storm surges, especially as coastal regions lose key buffer vegetation. Fourth, the alteration of natural spaces and the introduction of foreign species might lead to unpredictable mutations that could eventually destabilize the entire planet.

The Business Role and Imperative to Act

Business has much at stake in the biodiversity crisis. The decline of natural ecosystems creates significant risks for companies, including an erosion of their social license to operate. In a recent BCG survey of 3,000 people across eight countries, 87% of respondents said that they expected companies to integrate environmental concerns into their operations and that companies receiving government aid should take on extra environmental responsibilities. At the same time, however, the crisis creates opportunities for businesses that take the lead in protecting biodiversity.

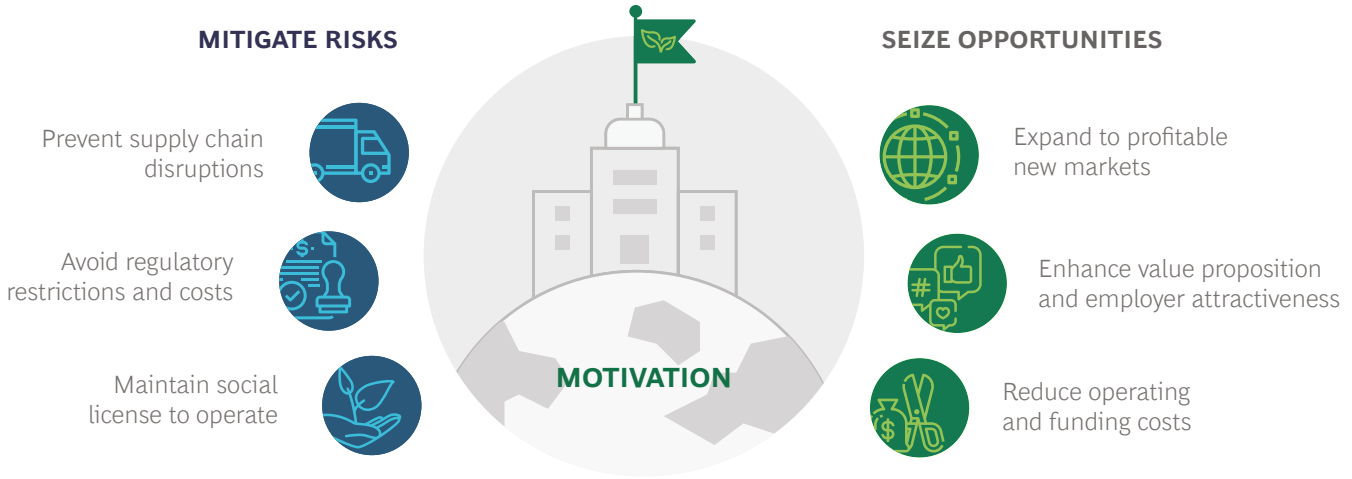
Momentum for action is building. According to a survey by GlobeScan and SustainAbility, business executives now consider biodiversity loss the second-most urgent sustainability challenge. Major business organizations such as the WEF and the World Business Council for Sustainable Development are calling for a biodiversity-friendly transformation of the global economic system. Although the need for action extends across all of the world's major value chains, a close look at the activities that fuel biodiversity loss—including primary-sector activities such as resource extraction and farming—reveals that four value chains have an especially outsized impact today: food, energy, infrastructure, and fashion.

The Burning Platform for Business

Companies need to move aggressively in support of biodiversity. Forward-looking players understand this. For example, a number of multinational companies have formed the One Planet Business for Biodiversity (OP2B) coalition to drive action. They are motivated by a clear understanding that continued biodiversity loss creates significant risks for their business—and that as an early mover they stand to benefit from new business opportunities and improved standing with customers and investors. (See Exhibit 4.)

Risks. Businesses face three main biodiversity-related risks. First, the decline of natural ecosystems threatens to disrupt many important supply chains. Obviously, sectors that depend on natural resources—and therefore on provisioning ecosystem services—are in danger of incurring increased input costs as biodiversity declines. Food producers could face higher costs as natural pollinators are lost and agricultural lands suffer from contamination and continued erosion. Nestlé Waters, for example, spent almost €25 million over the course of seven years to help farmers adopt biodiversity-friendly practices and reduce contamination around the source of its Vittel mineral water in the Vosges Mountains. Pharmaceutical players could take a hit as well: one-third of medical treatments are based on natural products. And the tourism industry in many parts of the world depends on the preservation of natural wonders and wildlife. The impact of a looming decline of natural regulatory functions will be felt well beyond industries that rely on natural inputs for their production, however. For example, if mangroves disappear, coastal flooding—which researchers say already threatens assets worth up to $14 trillion worldwide—could grow even more dire. And if the Amazon ecosystem collapses, enormous amounts of carbon will be released into the atmosphere, causing a devastating rise in global temperatures. Overall, few companies are aware of the magnitude of the physical risks that biodiversity loss poses, whether those risks relate to society as a whole or to their business directly.

Exhibit 4 - Six Biodiversity-Related Risks and Opportunities Motivate Companies to Act



Source: BCG analysis.

Second, pressure on business from governmental regulations related to biodiversity is increasing, a development that may impose significant additional costs in the future. The EU recently published its 2030 Biodiversity Strategy and Farm to Fork Strategy, outlining regulatory plans to intensify protection efforts, promote biodiversity-sparing land-use models, reduce the discharge of chemicals, and adopt circular-economy principles. Since 2011, the so-called Aichi targets, which the 190 member countries of the UN Convention of Biological Diversity (CBD) established to halt biodiversity loss by 2020, have provided a global-scale regulatory framework. None of those targets were met, however—and now, with a post-2020 framework set to be adopted at the upcoming 2021 CBD meeting, NGOs, companies, citizens, and national governments want to see that framework mimic the Paris accord, with simple, ambitious targets, a roadmap to achieve those targets, and nationally determined contributions. Such global and regional initiatives are likely to yield stricter environmental legislation in many countries, which could lead to the imposition of operating restrictions, the taxation of harmful activities, or the levying of fines against companies that fail to adjust their business. For example, in France, the ***devoir de vigilance*** already requires companies of a certain size in certain sectors to publish and implement a surveillance plan that includes goals for managing environmental risks and preventing serious environmental damage.

Third, companies that fail to address their negative impact on biodiversity put themselves at risk of eroding the goodwill of their customers and other stakeholders and, as a result, having a diminished social license to operate. This may result in declining consumer demand and difficulties in soliciting funding. A 2019 report coauthored by BCG, Global Fashion Agenda, and the Sustainable Apparel Coalition found that more than one-third of consumers surveyed reported switching from their preferred brand to another as a result of sustainability concerns. At the same time, some major global asset managers have demonstrated increased attention to environmental priorities, integrating environmental, social, and governance (ESG) performance into their investment decisions and excluding low performers on these measures from their portfolios. In addition, a recent BCG analysis found that the percentage of biodiversity-related news coverage that presents industries such as agriculture, energy, and paper or plastics manufacturing in a negative light increased steadily between 2014 and 2019.

Opportunities. Companies that lead on biodiversity will have significant opportunities to benefit from their efforts. First, they will be positioned to enter profitable new markets by developing valuable new products, services, and business models. For example, in agriculture, development of new precision farming technologies can improve land productivity while reducing the strain on cropland soil and surrounding waterways. For their part, crop protection and fertilizer companies can shift focus from increasing the volume of product sold to developing higher-value offerings that provide the same level of protection at lower volume. Meanwhile, a recent BCG study concluded that the global need for climate change mitigation technologies—including those for renewable and distributed power generation; energy-efficient heating, ventilation, and air conditioning; and carbon capture—will yield business opportunities worth a total of more than $10 trillion through 2050 for machinery makers. And governments may adopt regulatory frameworks that allow companies to earn a return on investments in preserving or restoring ecosystem services. For example, another recent BCG study found that Indonesian shrimp farmers could earn more by certifying carbon storage through intact mangrove forests than through continued shrimp harvesting, which often destroys mangroves. All told, the annual worth of business opportunities from nature protection could be as much as $10 trillion, according to the WEF.

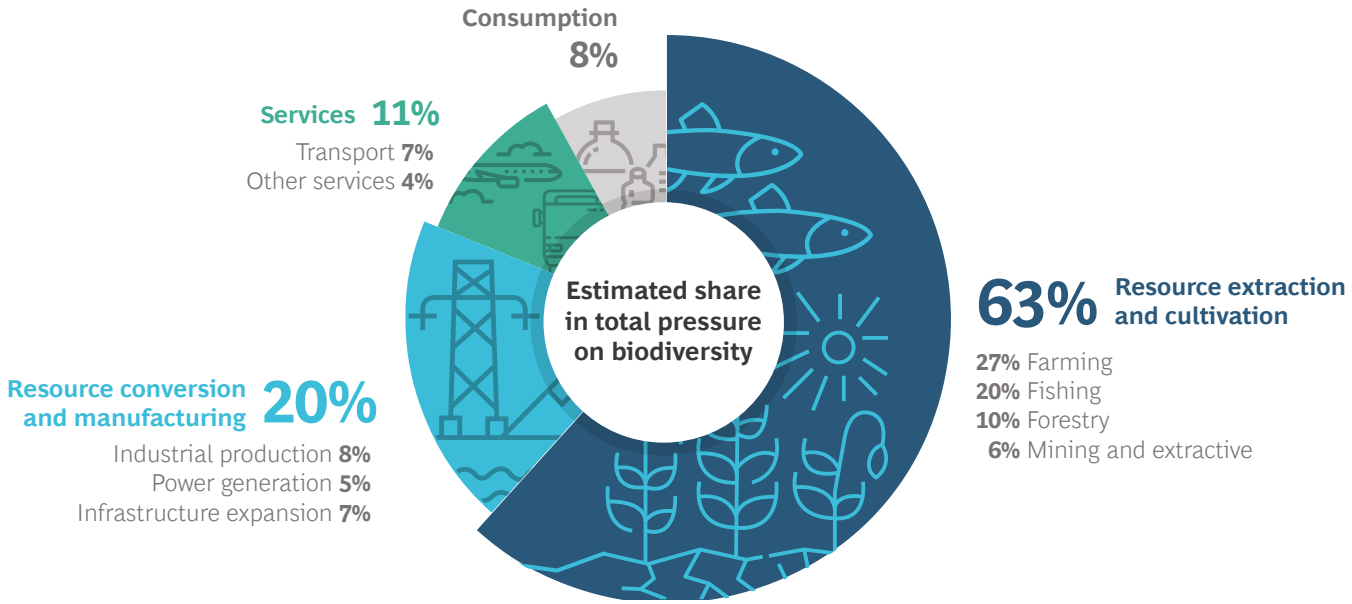
Second, biodiversity-oriented businesses have the opportunity to improve their value proposition and their brand by responding to public demand for sustainability. BCG's recent 3,000-person survey found that 88% of respondents were concerned or very concerned about biodiversity loss. As public awareness and concern grows, companies that have a credible narrative regarding their commitment to biodiversity may benefit from enhanced customer loyalty and increased revenue, particularly in consumer goods industries such as fashion and food. According to the NYU Stern Sustainable Share Index, sustainably sourced, produced, and traded products represent only 17% of the US consumer goods market, but they accounted for 50% of growth from 2013 to 2018. A strong sustainability brand can also create an edge for companies as they compete to attract and retain the best talent.

Third, companies that lead on biodiversity will see cost benefits from better access to capital and potential operational synergies. Investors are increasingly integrating ESG performance into their decision making—and market valuations reflect that practice. A BCG analysis found that—all else being equal—companies that outperformed their rivals on important ESG topics had higher valuations than median performers. The analysis showed, for example, that oil and gas companies that were top performers in certain ESG topics had a 19% valuation multiple premium. It also found that—along with maintaining process-oriented health and safety programs and avoiding and combating corruption—reducing the impact on biodiversity, water, and ecology was a driver. In the years ahead, biodiversity is likely to become an area of increasing focus for investors. In May 2020, 30 major European investors representing some €6 trillion in assets under management publicly called for creation of a biodiversity impact measurement framework. For their part, over the next few years, governments around the world are likely to implement green stimulus packages that provide subsidies or other benefits to companies that promote sustainable practices. Finally, companies that improve their efficiency in using resources such as raw materials, energy, and water can reduce their biodiversity footprint and realize operating cost savings. For example, by recovering and reusing byproducts of their manufacturing processes, industrial companies may be able to reduce both waste and input costs.

Business Activities Contributing to Biodiversity Loss

Although the risks and opportunities associated with biodiversity loss are relevant across all industries, some activities are especially prone to fueling the pressures outlined above. Understanding where biodiversity impacts arise helps identify which businesses have the most leverage to address the crisis and where they should look to take action. (See Exhibit 5.)

Exhibit 5 - Resource Extraction and Cultivation Activities Account for Most Pressure on Biodiversity



Source: BCG analysis (see the appendix for details).

We clustered activities that contribute heavily to biodiversity degradation into four categories along the economic value chain and estimated their biodiversity impact as follows:

- **Resource Extraction and Cultivation.** The largest impact, accounting for more than 60% of overall pressure, involves primary-sector activities—in particular, farming, fishing, forestry, and mining and extraction of fossil resources. These activities often entail land-use change and direct overexploitation of natural resources. Consider farming. The development of farmlands for livestock and crops is responsible for 80% of global deforestation. And by turning diverse natural ecosystems into homogeneously vegetated areas, farming is a major reason that approximately 40% of global insect species are nearing extinction. Furthermore, of the 20 million to 25 million tons of phosphate used annually as agricultural fertilizer, roughly 40% wind up being released into inland waters, rivers, and eventually the ocean, where they produce dead zones. Fishing has an impact nearly as great as farming, primarily through overharvesting of fish and other forms of seafood. Forestry accounts for a much smaller proportion of deforestation than farming does, but it can cause species-rich forests to decay through inadequate management practices. Finally, mining and oil and gas activities can exert several types of pressure on biodiversity, including land-use and sea-use change during exploration and decommissioning; soil and water pollution; and the release of GHGs in the course of extraction and processing.

- **Resource Conversion and Manufacturing.** This category includes three major activities—industrial production, energy generation, and infrastructure construction—that collectively account for roughly 20% of the pressure on biodiversity. Industrial sites such as petrochemical plants, steel and aluminum factories, cement works, textile factories, and pulp and paper mills are major sources of pollutants—including heavy metals, toxic solvents, and nutrients. Unless properly treated or captured, those pollutants accumulate in neighboring ecosystems and food chains. Industrial production is also a major cause of GHG emissions, accounting for almost 20% of the global total. Power generation accounts for another 30% of emissions, mainly through the combustion of oil, gas, and coal in large-scale plants. And infrastructure development is a dominant driver of habitat loss from soil sealing, ecosystem modification, and habitat fragmentation (which especially results from linear structures like roads).

- **Services.** Transportation and mobility services, such as those involved in the travel industry, put pressure on biodiversity through the burning of fossil fuels. Other service activities such as health care can be significant producers of chemical and solid waste, including some hazardous waste.

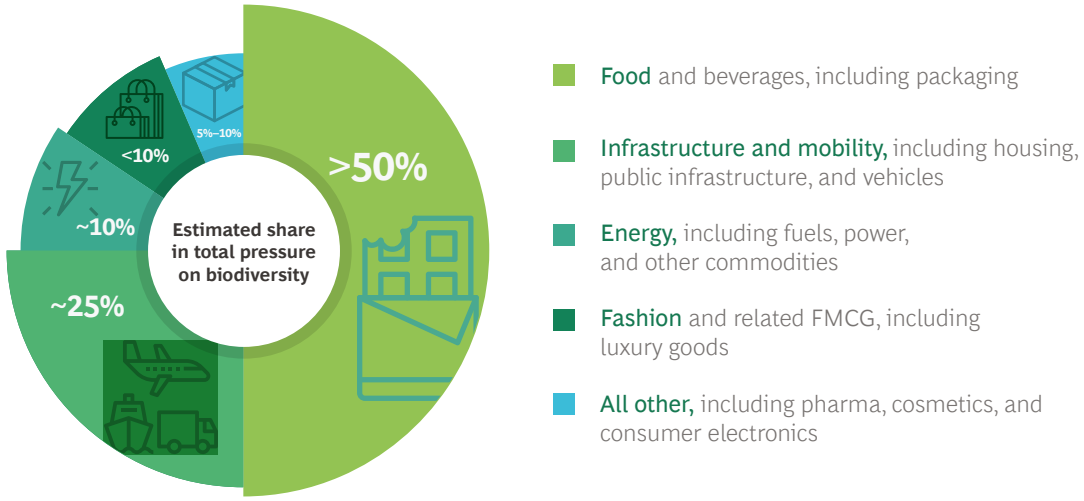
- **Consumption.** Consumers directly affect ecosystems through subsistence activities, the use of products with poor environmental profiles, and the inappropriate disposal of plastics, synthetic rubber, batteries, electronic waste, and other nonbiodegradable materials. Although private consumption is directly responsible for less than 10% of the pressure on biodiversity, the development of consumer end products ultimately drives all the aforementioned activities.

The Role of Major Value Chains

Activities that contribute to biodiversity loss occur in virtually every major value chain in the global economy. To make it easier for companies to understand how their business may be linked to biodiversity loss, we have classified value chains according to their consumer end products. Four of these collectively account for roughly 90% of biodiversity loss: food, infrastructure and mobility, energy, and fashion. (See Exhibit 6.)

Some activities, such as farming, fit primarily within one value chain. Others, including most industrial production activities such as chemicals production, are part of multiple value chains. In addition, there are significant linkages between some value chains. For example, fuel produced in the energy value chain is used to power vehicles developed in the mobility and infrastructure value chain.

Exhibit 6 - Four Major Value Chains Account for About 90% of Pressure on Biodiversity



Source: BCG analysis (see the appendix for details).

Note: Value chains are defined by consumer end products; FMCG = fast-moving consumer goods.

Although other value chains, such as consumer technology, also contribute to a high level of biodiversity loss in certain localities, we focus here on the four dominant value chains, assessing how they connect to natural ecosystems and identifying what specific activities within each contribute to the different pressures on biodiversity. (See Exhibit 7.)

The types of inputs and machinery used in each value chain, captured in its first phase, significantly influence the biodiversity footprint of subsequent stages. In addition, each value chain involves the generation of significant quantities of emissions in the course of transporting materials and goods during upstream and midstream processes, which are not shown as separate steps.

Food. The food value chain depends greatly on healthy levels of biodiversity. For example, all agricultural output—whether it is produced for direct human consumption or for use as feed for livestock—relies on healthy, fertile soil, and most food crops depend on natural pollinators such as bees. Similarly, the fishing sector depends on healthy aquatic ecosystems.

Biodiversity is critically important to the food value chain, and yet that value chain drives natural ecosystem deterioration, accounting for more than 50% of man-made pressure on biodiversity. The largest negative impact comes through farming and fishing activities, which directly involve the conversion and exploitation of ecosystems. Later-stage activities have an impact through emissions from food processing, propagation of invasive species during distribution, and consumer packaging waste.

Consumer diets are a major factor in the impact of the food value chain. Worldwide, there is a distinct lack of diversity in human diets, with nine crops accounting for 66% of global food production, according to the UN Food and Agriculture Organization (FAO). This lack of diversity is reflected in the widespread prevalence of monocultures, which exacerbate soil degradation and the decline of local species. The global spread of Western-style, meat-heavy diets drives several forms of pressure on biodiversity, including massive land conversion for soy cultivation. (See the sidebar "The Biodiversity Impact of a Steak.") A BCG study found that if external costs of agriculture, including the loss of valuable ecosystem services, were internalized in food prices, prices in Germany would be more than three times higher for products such as beef, poultry, and wheat. Ultimately, reducing the harmful impact of farming on biodiversity will require consumers to shift toward diets with less meat and more diverse, locally grown food, and it will require the food industry to change how it cultivates and produces food.

Exhibit 7 - Biodiversity Impact of Four Major Value Chains

Source: BCG analysis.

[1]Includes transport of crops, livestock, and raw materials.

[2]Includes transport of raw materials.

[3]Both energy and infrastructure value chains can influence the impact of mobility.

The Biodiversity Impact of a Steak

Around the world, diets tend to rely too much on meat. The EAT-Lancet commission found that daily meat consumption globally is more than double the recommended amount as gauged in terms of health and environmental impact. That has major implications for biodiversity. A close look at the life cycle of a steak reveals why.

First, cattle farming requires massive acreage for grazing areas and for soy plantations to produce feed— acreage often created through the conversion of pristine forests or wetlands, destroying natural habitats and releasing significant amounts of CO_2. For its part, soy is often grown in monocultures and treated with intensive techniques such as surface irrigation and large amounts of synthetic fertilizers and plant protection products. These activities can be significant drivers of local soil and water pollution. All in all, a regular-size (250-gram) steak is estimated to require around 5,000 liters of water and more than 10 kilograms of feed, according to academic research. In addition, cattle farming creates significant emissions of the GHGs methane and nitrous oxide. Subsequently, the production of plastic packaging material for the steak requires petroleum, whose extraction and refining drive land-use change and air pollution. The meat is processed, packaged, and then transported to a retail store, again creating GHG emissions. And finally, the steak is consumed, and the discarded plastic packaging may wind up in freshwater ecosystems and eventually the ocean.

Infrastructure and Mobility. In this value chain, we include the development of housing, public buildings, technical infrastructure such as telecommunication networks, and transportation infrastructure, as well as the production of vehicles. We exclude private-sector infrastructure such as factories because we account for them in the value chain in which they operate.

Although the development of infrastructure and mobility equipment doesn't rely on biodiversity to the same extent that the food value chain does, it is hardly insulated from ecosystem degradation. More than 20% of the global population lives in areas where protection of critical infrastructure depends heavily on such regulating ecosystem services as climate regulation, erosion prevention, and flood mitigation through mangrove forests and other vegetation.

Infrastructure value chains are long and opaque, and they contribute about 25% of the pressure on biodiversity. First, the exploration of mining sites drives habitat conversion; and the subsequent extraction of raw materials such as sand, rock, and metal ores creates both GHG emissions and a high risk of soil, water, and air pollution. Production processes then convert these inputs into building materials, such as cement, and wrought materials—while also creating significant quantities of hard-to-abate emissions of CO2 and air pollutants, and, in the case of metallurgy, requiring large amounts of freshwater. The assembly of infrastructure components and vehicles likewise involves some emissions. Finally, infrastructure development drives land-use change, including the construction of lengthy infrastructure elements—such as highways, roads, and railways—across previously pristine ecosystems, and the diversion of natural waterways. Beyond sealing ecosystem areas, such developments often involve fragmenting habitats, which can destroy vital mating, feeding, and migration grounds for local and transient animal species. According to the International Union for the Conservation of Nature, almost 40% of global habitat loss is the result of infrastructure expansion. Such issues will become more urgent in the years ahead: the UN FAO expects that by 2050 an additional 100 million hectares of land—much of it in countries that host vital ecosystems—will be converted to housing, industries, transport networks, and other infrastructure.

Energy. The energy value chain, which comprises all activities related to the provision of power and heat, depends only partially on biodiversity. Although fossil fuels such as oil, coal, and gas have a significant capacity to disrupt the world's natural balance, they form over thousands of years in isolation from above-ground ecosystems. Even so, roughly 10% of primary energy (energy as found in nature before it is converted) is supplied through biological feedstocks to be used in fuels, heating, or electricity generation. Moreover, the energy value chain risks disruption if the declining regulating capacity of ecosystems leads to increasingly frequent disasters that damage critical infrastructure.

The energy value chain accounts for an estimated 10% of man-made pressure on biodiversity—not including the impact of industrial heating, which we allocate across other value chains. First, the extraction of coal, oil, gas, and other fossil fuels can disrupt terrestrial and deep-sea ecosystems. A single fracking well, for example, uses more than 10 million liters of freshwater during its lifetime, along with 60,000 to 200,000 liters of chemicals that, without proper controls, can seep or run off into surrounding waterways. At the same time, significant impact arises during the generation of electricity from those fuels, as large-scale power plants and distributed generation facilities release GHGs. In fact, if all environmental costs were factored in, the true cost of coal-based electricity for consumers would be at least 10 to 27 cents per kWh higher—roughly 100% to 200% above current US prices—according to a 2011 study by the Harvard Center for Climate, Health, and the Global Environment. Even clean energy sources have an impact: renewable energy plants often significantly interfere with local habitats. Meanwhile, the refining of fuel for mobility and the eventual burning of those fuels in consumer vehicles create additional CO2 emissions. And finally, the development of energy infrastructure such as pipelines and transmission lines can drive severe habitat loss.

Fashion. Like the food value chain, fashion depends heavily on biodiversity. Roughly 25% of textile fibers and more than 50% of apparel are cotton based. And like the food value chain, the fashion value chain has a large biodiversity footprint. The most significant impact occurs at three distinct stages: during farming and raw materials extraction for the production of natural and synthetic fibers, during the production of fabrics, and during consumer usage and disposal.

The degree to which textile production affects biodiversity depends in part on the raw material used. Cotton production, for example, involves all of the aforementioned biodiversity risks from farming and, in particular, consumes high volumes of freshwater. According to the WWF, the cultivation of the cotton needed for a single t-shirt requires around 2,700 liters of water and often occurs in already water-stressed areas. Meanwhile, the production of leather and furs may involve overexploitation or displacement of local species, and the development of cellulosic fibers such as viscose can be a major driver of overlogging. And processes for sourcing and producing synthetic fibers, which are largely petroleum based, involve habitat conversion and pollution risk. Once the material is in hand, the process of producing fabric from it is a major source of chemical water pollution, including from dyeing and leather tanning, which produce byproducts containing diverse hazardous components such as chromium. GHG emissions occur at almost every step—including in raw material extraction, fabric production, clothing assembly, and distribution—and after usage. In fact, globally, 73% of disposed clothing is burned or buried in landfills. Finally, consumer usage of fashion goods can be a driver of plastic pollution, from the unsafe disposal of products and packaging, and also through microplastics that come loose during cleaning and care.

Building a Biodiversity-Positive Business

To arrest or reverse large-scale biodiversity loss, companies across value chains must transform their businesses. Many have already begun that journey by addressing their key areas of impact and developing ways to protect and support natural ecosystems.

We have developed a four-stage approach for companies that aspire to become biodiversity-positive businesses (see Exhibit 8):

1. Determine the appropriate scope of action to take on biodiversity, in view of the company's impact and dependence on natural ecosystems along its value chains, with a particular focus on impacts on key biodiversity areas.

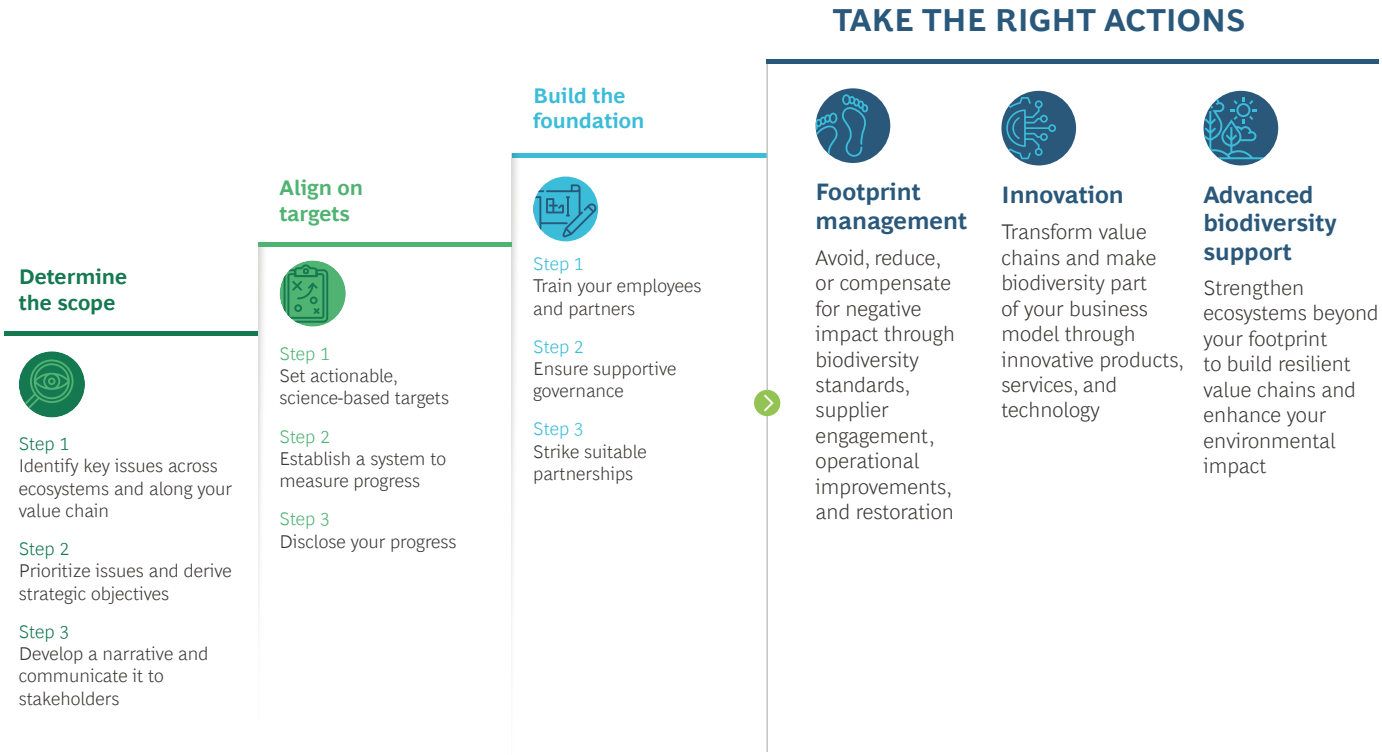
2. Align on science-based targets, and establish systems to measure and report progress toward those targets.

3. Build a foundation for success, including assembling a trained and incentivized staff and developing strong partnerships.

4. Take the right actions through a combination of initiatives in biodiversity footprint reduction, innovation, and advanced biodiversity support beyond the company's own impact.

Because of the position they hold in their value chain, some companies can take actions that have far-reaching impact. In the food value chain, for example, suppliers of machinery and agricultural inputs such as seeds and fertilizer are in a strategic position to influence the activities of farmers and fisheries (which have relatively low margins and little bargaining power). Similarly, retailers have a significant amount of leverage, given their knowledge of consumer needs and ability to steer demand. Regardless of their value chain position, however, companies must move beyond mere declarations of intent and actually deliver meaningful and locally measurable benefits for ecosystems.

Exhibit 8 - The BCG Framework for a Biodiversity-Positive Business



Source: BCG analysis.

Determine the Scope

Companies committed to counteracting biodiversity loss must start by setting an appropriate scope for their overall effort. Drawing on the work of the Science Based Targets Network (SBTN), which recently published detailed draft guidance for companies on setting and operationalizing nature (including biodiversity) targets, we recommend three steps.

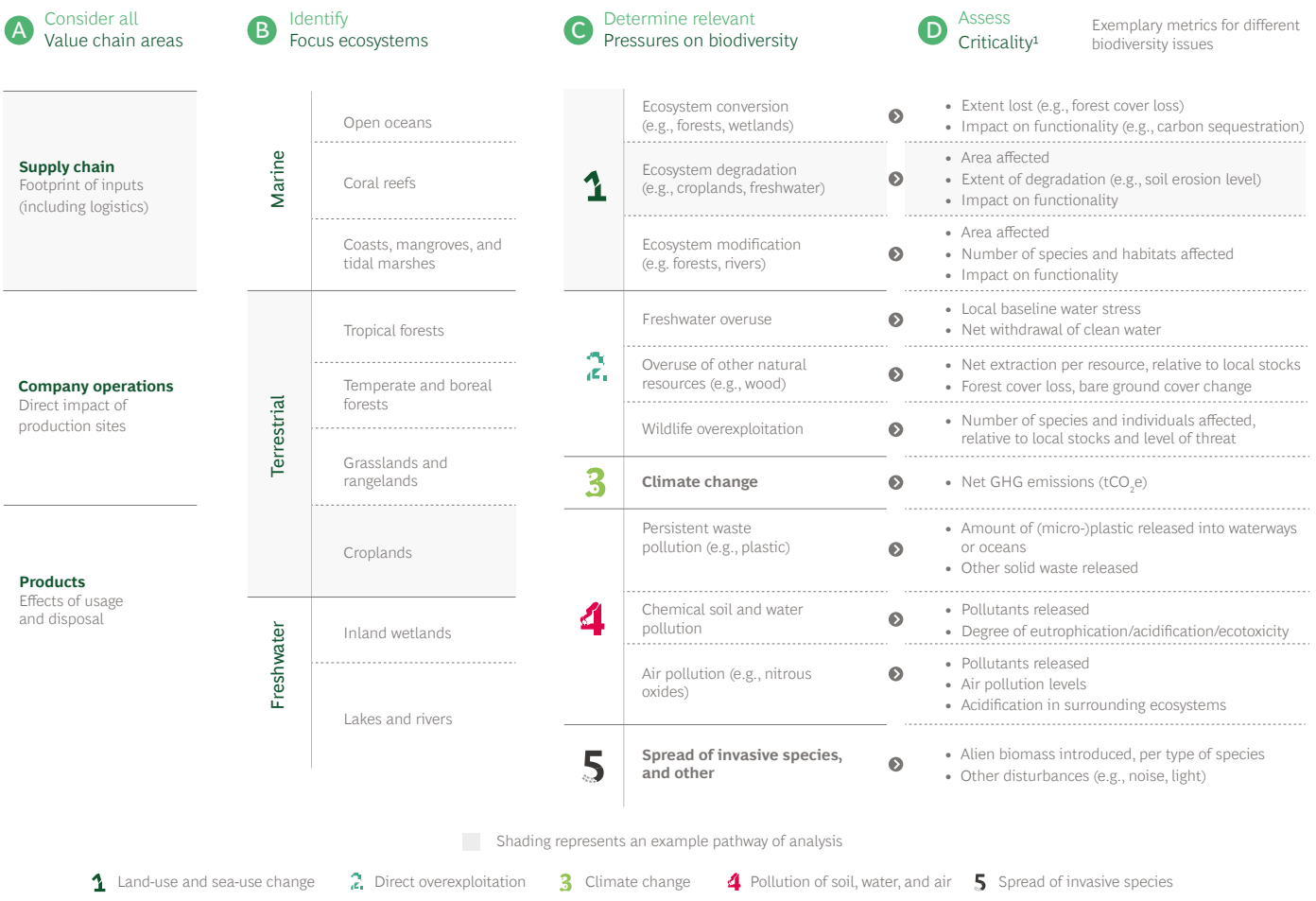
Step 1: Identify Key Issues

The first—and in many ways most critical—step for each company is to zero in on its most critical biodiversity issues. The analysis should include the company's sites of operation and those of its suppliers of raw materials, components, energy, or services—and the impact of how consumers use and dispose of the company's products and services. (See Exhibit 9.)

For each of those categories, the company should assess three factors:

- **Focus Ecosystems.** Which ecosystems are concerned?
- **Pressures on Biodiversity.** What are the pressures, and what is my role in causing them?
- **Assessment of Criticality.** Which issues are most urgent?

Exhibit 9 - A Framework for Identifying Key Biodiversity Issues



Sources: Science-based Targets Network; BCG analysis.

Note: tCO_2e = tons of carbon dioxide equivalent.

[1]Suggestions for KPIs, not exhaustive.

That last question will help guide the company's actions. An assessment of criticality should address three issues: the state of the ecosystems in question and the magnitude of pressure on them; the importance of those ecosystems to society in general and to the company's value chain in particular; and the company's contribution to the pressures (its biodiversity footprint). In evaluating its footprint, the company should adopt a spatial lens and identify where its business contributes to the degradation of the local landscapes in proximity to it, particularly with regard to key biodiversity areas. Beyond that, the company must keep in mind that even if it is not contributing significantly to the degradation of a specific ecosystem, it may need to take protective action if its operations depend on the ecosystem's continued health.

Relevant indicators of ecosystem health (such as species abundance and size of intact ecosystems) and the company's environmental impacts (such as pollutants released and net loss of clean water) differ by the pressures in question. A host of tools are available to track this information and help the company understand both its footprint and its dependencies. (See the appendix for more details.)

Step 2: Prioritize Issues and Derive Strategic Objectives

Once a company understands its most urgent biodiversity issues, it needs to identify the areas to prioritize for action. To answer this question, it should assess issues on the basis of two criteria:

- **Materiality.** The materiality of an issue depends on two factors. The first factor is the degree to which the issue could impact the business directly. If, for example, the issue negatively impacts an ecosystem service that the company depends on, that issue is material. The second factor involves the expectations of stakeholders, including regulators, investors, customers, and employees. Issues that are the subject of existing or future regulations are likely to be a higher priority. An issue will be more material if it is likely to impact investor views of the company, consumer demand, and the needs of employees and local communities. In assessing materiality, a company should also factor in approaches taken by its competitors; issues already championed by others in the industry may become an area of focus for stakeholders.

- **Control.** The company should apply a broad lens to its sphere of influence. First, it should strive to own what happens throughout its entire value chain, including among suppliers and customers. For example, a fashion retailer does not have direct control over land conversion or water pollution that may occur as a result of cotton cultivation. But the company can adopt sourcing standards that require suppliers to verify how inputs were produced—and thus drive supply-chain changes all the way through to farming practices. Second, it should consider its impact on production and consumption patterns at large—and it may try to influence consumers' purchasing decisions toward more sustainable diets, for example.

After prioritizing its major biodiversity issues, the company needs to translate them into strategic objectives. BCG has identified 15 objectives that, if broadly achieved around the world, would prevent much of the biodiversity harm that economic activities currently cause. (See the sidebar "Overarching Biodiversity Objectives for Business.") The company should draw on those broad objectives to determine specific business-appropriate strategic objectives that match its biodiversity footprint. For example, if it identifies deforestation at supplier sites in tropical forests as a key issue, one of its strategic objectives may be to create a deforestation-free supply chain.

Step 3: Develop and Communicate a Narrative

Finally, the company should create a narrative to guide its biodiversity action. As the company takes steps to reduce its impact on biodiversity, it should disseminate the narrative both within the organization and to outside stakeholders such as consumers, investors, and regulators.

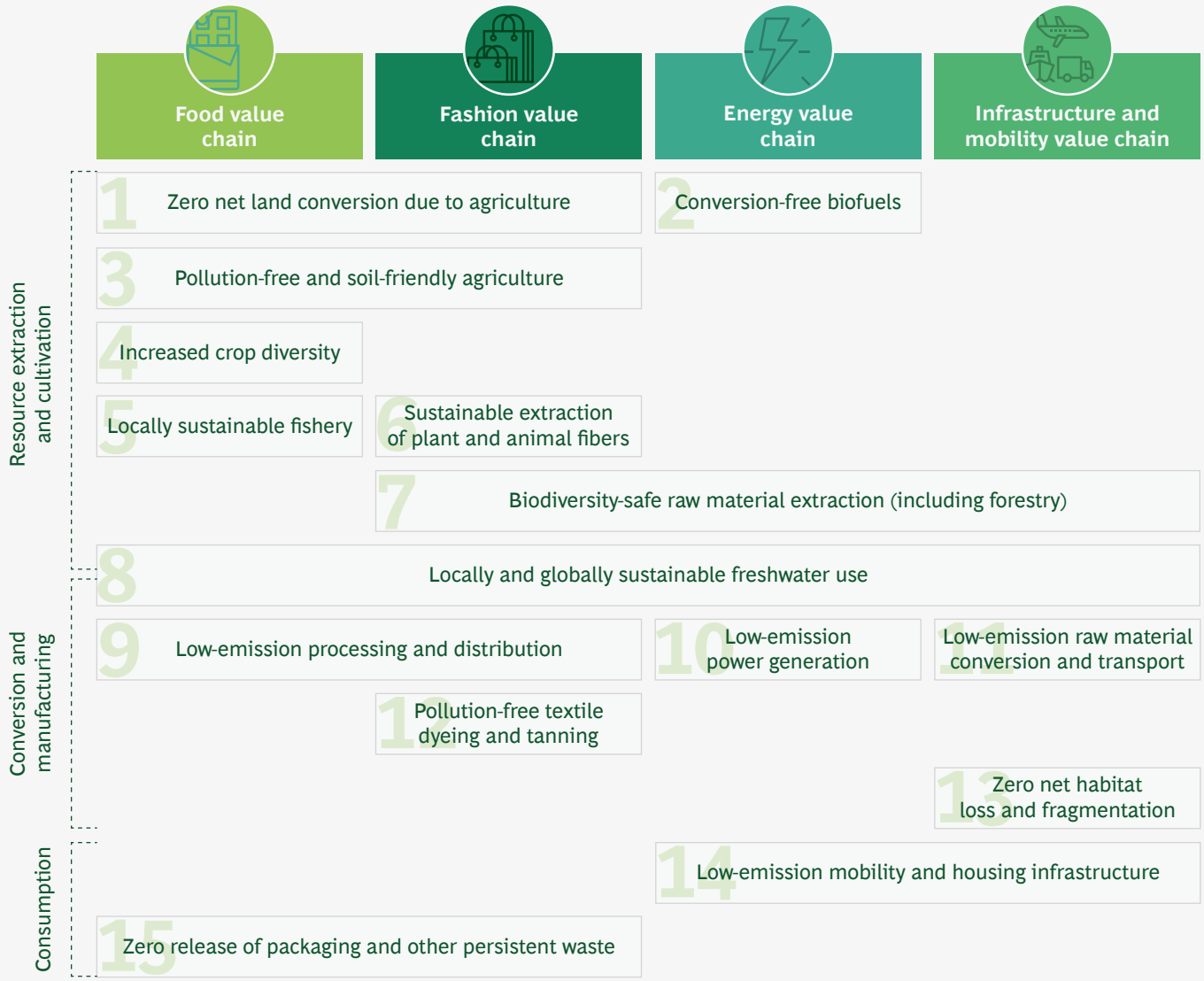
The narrative should express clear ambitions that are consistent with the company's strategic objectives but are also sufficiently high-level that stakeholders can relate to them. For example, Danone has committed to sourcing 100% of its ingredients produced in France from regenerative agriculture by 2025. HP has made a range of commitments to sustainable impact, including pledging that every page printed on an HP machine will be forest positive, carbon neutral, and part of a circular economy (meaning recycled after use). And cement maker CRH has set a target of developing biodiversity management plans for 100% of its sensitive extraction sites by 2030.

Overarching Biodiversity Objectives for Business

Given the many ways in which the world's value chains contribute to pressure on biodiversity, businesses need objectives to guide them in reducing their impact. In global efforts to combat climate change, a single corporate objective has emerged: achieving net-zero emissions. There is a push from various NGOs, nonprofits, and other groups to come up with a similarly broad objective with regard to biodiversity: to eliminate any negative impact on ecosystems and become nature positive. That broad goal requires companies to take steps to minimize their impact in key biodiversity areas and to adopt practices that reduce multiple pressures on biodiversity generally. In practical terms, that means setting specific objectives that address the most urgent issues at the local level. Our research indicates that 15 objectives could significantly move the needle on preserving biodiversity. (See the exhibit.)

Several of these objectives, such as locally sustainable freshwater use, are relevant for all major value chains. Others, such as pollution-free textile dyeing and tanning, apply to specific value chains. For value chains other than the four we examine in detail in this report, additional objectives will guide action—such as the objective of producing paper without chemical pollution or reducing electronic waste from consumer technology.

Fifteen Key Biodiversity Objectives for Business



Source: BCG analysis.

Note: Not exhaustive due to focus on four value chains.

Align on Targets

To integrate its strategic objectives into operations, a company must take three steps.

Step 1: Set Actionable, Science-Based Targets

The company must translate its strategic objectives and the high-level targets it communicates to stakeholders into more detailed and actionable, science-based targets. Formulating detailed targets will enable the company to select specific local initiatives and evaluate progress toward them.

SBTN is in the process of developing comprehensive guidance for target setting. Companies can draw on these insights to break down targets by geography, product, or business unit, setting a timeline for each. In addressing the objective of creating a deforestation-free supply chain, for example, a company would translate that objective into several targets—such as increasing its share of certified deforestation-free inputs by a specific percentage within key regions that are subject to deforestation.

Step 2: Establish a System to Measure Progress

Once it has set specific targets, the company should establish a system that helps it develop locally suitable initiatives to address high-priority issues and track the progress of the initiatives in terms of inputs, direct outputs, medium-term outcomes, and long-term impact on ecosystem health. (See Exhibit 10.)

Tracing changes in ecosystem health to initial inputs—actions taken and labor and capital expended—is a difficult exercise because every ecosystem is unique in its composition, needs, and influence factors. (See the sidebar "A Deep Dive into Marine Ecosystems.") To facilitate impact measurement, a company can invest in building proprietary tools. For example, Dutch dairy cooperative Friesland Campina developed the Biodiversity Monitor, which evaluates ecosystem diversity, species diversity, and ecosystem functionality on pasturelands. Other companies may draw on the broad array of biodiversity tools available today.

Step 3: Disclose Your Progress

Third, the company should publicly disclose where it stands relative to the targets it has set—both at the start of its efforts and over time as it progresses toward its objectives. Beyond meeting the growing expectations of transparency held by investors, consumers, and other stakeholders, companies that disclose their biodiversity impact may inspire other players within their value chain or industry to take action. The work of initiatives such as SBTN and the Taskforce on Nature-related Financial Disclosures (TNFD) will increasingly facilitate the reporting of progress on specific biodiversity issues. But firms shouldn't wait, and some already include information on their environmental footprint—including biodiversity aspects—in their annual reports or publish dedicated environmental profit and loss accounts (EP&Ls). Puma publishes an extensive annual EP&L, reporting impacts throughout its value chain, including land use, water consumption, and GHG emissions. In addition, standard-setting bodies such as the Global Reporting Initiative and the Sustainability Accounting Standards Board now incorporate biodiversity criteria into their frameworks. Companies can use those frameworks to show stakeholders how their biodiversity record and ESG performance stack up to those of other businesses.

Exhibit 10 - Tracking the Effectiveness of Biodiversity Initiatives over Time

Immediate	Short-term	Medium-term	Long-term
INPUTS	**OUTPUTS**	**OUTCOMES**	**IMPACTS**
Measures for cost/benefit evaluations	Measures to track immediate effects	Measures of ecosystem use and condition	Measures of biodiversity health and functionality
Concrete actions Labor Capital	Reduction of pressures on ecosystems (e.g., resource overexploitation) Positive contributions to ecosystems (e.g., creation of a biotope)	Land in use Intact habitats Condition of soil, water, and air	Size of healthy ecosystems Species and genetics diversity State of ecosystem services
EXAMPLE Farmer invests in precision irrigation system	• Reduced extraction of water from neighboring ecosystems • Reduced washout of fertilizer and crop protection agents	• Better maintenance of watersheds and waterways • Reduced/avoided eutrophication of soils and water • Less chemical residue lingering in environment	• Increased area of thriving local habitats • Increased biomass and diversity among key indicator species • Higher ecosystem services value

Source: BCG analysis.

A Deep Dive on Marine Ecosystems

Companies must tailor the indicators they track to the ecosystem and issues they want to address. Consider the strategic objective of reducing a company's impact on marine ecosystems. All five of the major pressures on biodiversity are relevant factors in the decline of ocean biodiversity. (See the exhibit.)

As companies set targets to address those issues, they should identify the best indicators for tracking that impact, starting with simple output indicators. Companies that want to reduce the physical pollution of marine environments, for example, can track the amount of plastic waste entering oceans along their supply chain. They can draw on tools such as Plastic Scan and BCG's proprietary SDG 14 Dashboard to monitor such information. Subsequently, they should link those metrics to outcome and, eventually, impact metrics of ocean health and diversity. Tools that help identify relevant metrics for oceans include the Integrated Biodiversity Assessment Tool (IBAT) and Ocean+.

Picking Metrics to Track Impact on Marine Ecosystems

Strategic objective	Types of pressures	Key issues	Indicators of pressure (output metrics)
Zero negative impact on marine ecosystems	1 Land-use change	Transformation and artificialization of coastal and marine habitats	Area of converted habitats, by systemic importance and level of threat
	2 Direct over-exploitation	Depletion of living resources	Amount of living resources extracted, by systemic importance and level of threat
		Depletion of mineral resources	Amount of extracted deep-sea mineral resources and granulate
	3 Climate change	Effects of releases to the air (global warming, acidification)	Release of CO_2 and other GHGs; release of nitrous oxide and sulfur oxide emissions
	4 Pollution of soil, water, and air	Solid waste pollution of coastal and marine environments	Amount of plastic and other physical waste entering water
		Chemical pollution of coastal and marine environments	Amount of released contaminated wastewater, plant protection products, heavy metals, or acidifiers
		Other disturbances to coastal and marine habitats	Deviations from regular levels of sound and light
	5 Spread of invasive species	Release of invasive alien species into coastal and marine habitats	Invasive biomass released (from excess bait, sailing ballast, or aquaculture)

Sources: Science-based Targets Network; UNEP; BCG analysis.

Build the Foundation

Because biodiversity remains a somewhat underdeveloped topic in the corporate world, companies need to enhance and refine their existing sustainability capabilities to put their biodiversity strategy into action.

Step 1: Train Your Employees and Partners

A company should educate its employees about the importance of biodiversity generally and train them to integrate biodiversity concerns into their decision making.

Employees must understand the threats to biodiversity, why those issues matter, what the company's role is, and how they can pursue specific targets locally. For example, the Fashion Pact coalition is hosting webinars for member companies and their employees on the value of biodiversity, the impact of business on biodiversity, the development of science-based targets for nature, and the risk to biodiversity that is inherent in supply chains. Companies should extend relevant education and training to other stakeholders such as suppliers and customers.

Step 2: Ensure Supportive Governance

The company should integrate biodiversity targets with existing governance mechanisms to ensure that they receive the same attention as financial KPIs. To keep things lean, the company should integrate biodiversity initiatives within existing corporate structures such as wider sustainability teams, ongoing initiatives, or risk management systems.

In particular, the company should incentivize managers to include biodiversity targets in their decision making. It should develop employee performance targets, perhaps linked to variable compensation, that entail achieving controllable biodiversity impact metrics. And it can explore opportunities to set internal prices on adverse biodiversity impacts, similar to the internal carbon price that many companies have adopted. This would reward business units that successfully reduce their impact on certain biodiversity metrics.

Step 3: Strike Suitable Partnerships

The company should pursue partnerships to enhance its capabilities. Collaboration is especially critical in areas where costs and technology risks are high. Companies that partner can overcome such barriers by pooling resources, gaining access to technology, and sharing knowledge. Industry- and value-chain-wide coalitions such as the OP2B, the Fashion Pact, the Responsible Steel initiative, and the Alliance to End Plastic Waste are working to develop biodiversity-safe production systems. Companies that partner with NGOs can enhance their understanding of local ecosystems' needs. For example, many industry players partner with BirdLife, a conservation NGO, to develop resource extraction models that maintain and support the intactness and diversity of surrounding ecosystems. And Anglo-American is partnering with Fauna & Flora International to identify locally suitable ways to avoid, minimize, and reverse adverse impacts from mining.

Take the Right Actions

There is no universal blueprint for reducing a company's biodiversity footprint. Rather, each company must focus on the specifics of its business in selecting the right initiatives. These initiatives fall into three categories: managing the footprint, driving innovation, and embracing advanced biodiversity support beyond the company's own footprint. To identify appropriate initiatives, a company should consider its biodiversity objectives, the specific needs of relevant local ecosystems, and its network of suppliers, customers, and other partners. In addition, the company should design its effort in a way that leverages available assets. For example, some companies may own technology that supports the development of precise resource extraction or crop protection tools to reduce soil, air, and water pollution. Others may possess biotechnological know-how that enables them to unlock new revenue streams from food products requiring fewer crop inputs or from biofuels created by recycling food waste—both of which can reduce crop demand and deforestation.

The company should design initiatives with two principles in mind. First, they should serve the needs of local ecosystems—protecting pristine, diverse, and interconnected structures; reversing prior damage; and minimizing new damage from land use. Second, they must factor in the needs of local stakeholders such as smallholder farmers and indigenous communities.

Footprint Management

Companies should address footprint management goals along a spectrum known as the ***mitigation hierarchy***. First, they should try to avoid any interference with biodiversity. Second, where avoiding interference is impossible, they should reduce the negative impact. Third, they should seek ways to compensate for such impact by restoring ecosystems or supporting their natural regeneration.

The following moves can help companies achieve these goals:

- **Adopt biodiversity-safe operating standards.** Companies should establish standards to minimize the impact of their operations, using insights from the footprint analysis. These standards can reduce impact in several ways, depending on the value chain. A company in the primary sector can embrace standards that reduce interference with vulnerable or biodiversity-rich ecosystems, adopt locally suitable limits for the extraction of natural resources, and ensure safe processes that are adapted to local species' needs and the specifics of each season. A company that relies heavily on resource conversion and manufacturing activities, meanwhile, can adopt standards that reduce waste and emissions. NGOs and local public institutions can help in developing the right, locally appropriate standards. The Forest Stewardship Council (FSC), for example, worked with a coalition of actors along major value chains to develop standards that provide guidance on sustainable forest management.

- **Set sourcing standards and support suppliers.** Sourcing standards are a critical tool for retailers and manufacturing companies to use in reducing their impact on biodiversity, since their impact is often concentrated upstream. In cases where supply chains are transparent and companies enjoy good relationships with suppliers, the most impactful approach is to work directly with suppliers to establish good practices locally. For example, luxury brand company Kering has launched the South Gobi Cashmere Project to preserve rangeland biodiversity in Mongolia. The initiative educates and works with goat farmers to help them adopt practices such as optimized stocking rates and rotational grazing to support soil health, and it uses satellite monitoring to provide them with data on pasture quality and wildlife protection. In industries such as retail, where supply chains are often long and opaque, companies may need to rely on certifications or other strict measures to steer the biodiversity footprint of inputs. (See the sidebar "Sourcing Standards for Deforestation-Free Supply Chains.")

- **Improve process efficiency.** Companies should look for opportunities to optimize processes, particularly by harnessing automation and digital technologies, in order to reduce their impact on biodiversity. Such efforts, which are particularly important for companies engaged in resource conversion and manufacturing activities, often have an added benefit of boosting overall efficiency and saving money. Reducing production steps or the length of logistic cycles, for example, can slash both GHG emissions and the consumption of resources such as freshwater, bolstering eco-efficiency. Audi recently extended water treatment capacity at its Ingolstadt plant to enable the recycling and reuse of half of all wastewater produced onsite, thereby cutting its freshwater requirements by one-third. Transportation companies can reduce their fossil fuel consumption by optimizing routes and load management.

- **Embrace integrated, biodiversity-positive land use.** Beyond establishing operating standards, companies in cultivation and extraction-based industries can adopt practices to reduce ecosystem degradation and support local biodiversity. For example, farmers can adopt integrated farming techniques such as including wildlife corridors in their fields and preserving soil health through

Sourcing Standards for Deforestation-Free Supply Chains

Sourcing standards are a key lever for achieving upstream goals such as deforestation-free agriculture. Companies can adopt sourcing standards at four levels, depending on the degree of transparency into and control of their supply chain. (See the exhibit.)

The strictest standards, which trace where and how specific inputs are produced, offer the greatest transparency and control. Nestlé, for example, announced a collaboration with OpenSC, a BCG/WWF-initiated service that uses GPS tracking and blockchain technology to permit end-to-end tracking of the palm oil it sources from key tropical wilderness areas.

In cases where that level of direct input tracing is not feasible, companies can select suppliers that comply with well-defined certifications. Tesco (UK) and their suppliers have committed to exclusively source zero-deforestation soy by 2025, as certified by the Roundtable on Responsible Soy Association. And since 2018, Tetra Pak has sourced 100% of its paperboard from FSC-certified or FSC-controlled sources, thereby ensuring deforestation-free production and reducing its carbon footprint.

If certified inputs are unavailable, companies can limit their sourcing to regions of the world designated as having certain biodiversity-safe standards are in place. And if companies need to source from suppliers beyond those regions, they can exclude inputs from countries that pose a high risk of negative biodiversity impact, such as areas associated with illegal deforestation.

There Are Four Distinct Levels of Sourcing Standards

Product-specific input tracing

Supplier-level labels or agreements to guarantee input standards

Sourcing from regions designated as having biodiversity-safe standards in place

Restricted sourcing to countries with low levels of risk of biodiversity degradation

Source: BCG analysis.

mixed cropping and intercropping. OP2B members are fostering integrated cropland use through initiatives along the food and fashion value chains. Meanwhile, forestry companies can enhance forest resilience through practices such as creating buffer zones for wildlife, planting locally suitable vegetation, and leaving areas to natural regeneration. Veracel, an operation of forestry company Stora Enso in Brazil, deploys comprehensive biodiversity management practices, including controlled burning, leaving deadwood in place in forests, and maintaining a diverse forest structure. Furthermore, Veracel is dedicating around 50% of its local land to rainforest conservation and restoration.

- **Drive ecosystem restoration and support regeneration.** In cases where some disruption of delicate ecosystems is unavoidable, companies can take action to restore their health and maintain key ecosystem services. Restoration includes measures such as afforestation with local species and rewetting of former peatlands. Miners can take action beyond what is legally required in restoring disturbed ecosystems after mine closure and decommissioning—for example, by creating new healthy habitats with locally suitable vegetation and supporting the return of native animals. Companies leading infrastructure projects such as highways should relocate habitats if ecosystem damage at the project site is unavoidable. They can identify appropriate restoration and generation measures through consultation with locally knowledgeable NGOs, which often understand local ecosystems well, including whether they need time for natural regeneration free of human disturbance (also called *passive restoration*).

Innovation

Innovation is a key lever for companies to use in reducing pressure on biodiversity and honing competitive advantage. Companies can develop products and services—including by leveraging new technology—that cause less ecosystem disruption, depend less on natural resources, or facilitate the natural development of ecosystems. By investing in such approaches, companies can advance their strategic biodiversity objectives and make biodiversity part of their business model. There are four primary areas for innovation:

- **Develop biodiversity-safe (or biodiversity-safer) products.** Companies should reduce the biodiversity impact of existing products and make sure these do not harm ecosystems when used or disposed of. That means measuring a product's success through an environmental lens alongside its financial returns. Such efforts are already under way in the agricultural sector, where companies are starting to look closely at the total impact of their products—including both the benefits to farming productivity and the adverse impact on natural ecosystems—and at options to reduce the latter while maintaining the former. Some seed producers, for example, are breeding crops that are more resistant to pests and have an improved uptake of fertilizers, thereby reducing the need for crop-protection chemicals. For their part, packaging companies are developing new biodegradable products, and fashion players are studying how to phase out the use of toxic materials and mitigate the volume of microfibers that find their way into natural ecosystems. And consumer packaged goods companies are rolling out new products that have a more positive biodiversity profile. For example, Unilever has developed multiple textile cleaning and care products that reduce water use by customers.

- **Enable low-harm cultivation and extraction.** Forward-looking companies are leveraging big data, AI, and automation to develop minimally invasive cultivation and extraction techniques that spare biodiversity and provide cost efficiencies. These efforts represent a significant opportunity for agricultural players such as machinery makers and for chemical and technology companies. Technology players can help farmers reduce the volume of inputs applied through new products. They can provide farmers with tools that leverage aerial

imagery and data analysis of soil and plant health and pest infestation to improve their understanding of their crops. Other suppliers can develop advanced machinery that enables farmers to adopt more precise and biodiversity-friendly fertilization and crop protection methods. South African retailer Woolworths partners with Aerobotics, a producer of drones and analytics tools, to help farmers adopt data-driven crop protection that promotes early problem detection and targeted treatment. Innovation can also reduce overexploitation of water resources: digital technology could help farmers save approximately 60% of the water used for irrigation, according to the UN FAO.

- **Drive circular product design and production.** *Circularity* refers to the regenerative and continuous cycling of resources within closed loops, such as through the recovery and reuse of byproducts or dismantled end products. Circular business practices, which are relevant for all companies engaged in industrial production, contribute to several key biodiversity objectives. First, they reduce the need for virgin resources. Recycling electric vehicle batteries, for instance, can reduce the demand for lithium, cobalt, and other metals, thereby preventing some of the deforestation and other negative impacts that occur during extraction of those materials. Second, circular business practices facilitate low-emission industrial production. Heat recovery and reuse, for example, can significantly lower GHG emissions. Third, product recovery—including recycling rather than burning or burying used textiles in a landfill—can play a crucial part in minimizing physical waste. Forward-looking companies are already integrating circularity into their business. Apple recently set targets for the proportion of recycled material it will use for some inputs, including 100% recycled tin, 60% recycled plastics, and 100% recycled aluminum. Beyond their benefits to biodiversity, such actions can yield significant cost savings, new business opportunities, and supply chains that are more resilient and less exposed to negative developments in suppliers' countries. A recent BCG study found that if 50% to 70% of the inputs used by German companies today consisted of recycled materials, the resulting synergies and business opportunities would be worth a total of €140 billion to €200 billion.
- **Develop biodiversity-positive products and business models.** Companies can develop products and business models that don't just reduce negative biodiversity impact, but also actively support ecosystem health. Agricultural input suppliers can use their plant protection technology to develop new products that target invasive species, including those outside croplands. Or they may add soil-replenishing legume seeds to their product portfolio. Legumes can serve as a mechanism for improving overall soil health, and they offer alternatives to soy for feedstuffs. French farm cooperative Invivo has moved away from soy and toward the use of linseed and pulses in its feedstuffs, a shift that can enhance cropland biodiversity, increase the quality of subsequent crops, and relieve cattle farmers' dependence on soy cultures from regions subject to deforestation. In addition, food producers and retailers can develop and promote products that are based on a greater variety of crops than they do today, thereby enabling farmers to profitably expand the number of crops they cultivate. Companies should also embrace business models that indirectly deliver biodiversity benefits. For example, Norwegian machinery company Tomra has created a sensor-based sorting system to optimize resource recovery and minimize waste in the food, recycling, and mining industries. Meanwhile, companies that promote mobility-as-a-service models such as car sharing can reduce both mobility emissions and resource use.

Innovation can also deliver on some challenges underlying the enormous global demand for natural resources One such challenge is food waste. One-third of all food produced globally is lost or wasted. (See the sidebar "Tackling Food Waste.")

Advanced Biodiversity Support

Finally, companies can work to support biodiversity beyond their core business. Besides driving ecosystem health and resilience, such actions can enhance companies' sustainability credibility and reveal new business opportunities. These efforts are often most effective when done in collaboration with NGOs, governments, and other organizations. They include the following:

Tackling Food Waste

Forward-looking companies around the world are leveraging new tools and technologies to reduce the massive amount of food lost and wasted every year. Their actions help drive progress toward multiple biodiversity objectives, including conversion-free agriculture, pollution-free and soil-friendly agriculture, and locally sustainable resource and freshwater use.

Walmart, for example, launched Eden, an internal digital solution that calculates food freshness in real time and reroutes shipments to reduce spoilage. Portuguese retailer Sonae has launched a series of initiatives to reduce food waste in its operations, and initial results indicate that the effort could cut waste across the company's supply chain by one-third. The Italian startup Orange Fiber collects orange peels from retailers to produce 100% citrus-based textiles. And players in the global food value chain have set up multiple marketplaces such as Food Mesh and Full Harvest to sell and repurpose food that would otherwise be discarded because of cosmetic imperfections.

- **Engage in corporate ecosystem stewardship.** Companies can assume direct responsibility for a specific environmentally valuable location, particularly if that location is endangered and of vital importance to the company's operations. Possible actions include acquiring land outright for conservation, paying landowners and land users to undertake conservation measures, and actively supporting local environmental governance and the work of conservation NGOs. Companies should build support for such actions among a broad base of stakeholders, including locally affected communities. Retailer Marks & Spencer has successfully brought together a broad range of stakeholders in its work with the WWF to address water scarcity in multiple regions, including a project to improve water governance and drive sustainable strawberry farming in Spain. Stewardship can sometimes translate into new profitable businesses. In Indonesia, for example, companies can acquire an ecosystem restoration concession to foster the preservation of local rain forests. Partnerships for Forests, the managing NGO, has identified five potential sustainable business streams, including developing rubber, harvesting wild honey, and certifying environmental services. The latter involves earning credits for conserving and restoring ecosystem functions, a mechanism already used by companies that support carbon sequestration projects. Companies could similarly earn credits for protecting other ecosystem services, such as the formation of fertile soil. Existing programs include the Gold Standard and Verra's Climate, Community & Biodiversity (CCB) Standards. CCB alone has already certified 11 million hectares of conservation area and 10 million hectares of restoration area.

- **Generate data and insight.** New technologies such as sensors and aerial imagery create opportunities to collect vast amounts of data and generate insights on the development of ecosystems and the success of preservation measures. Companies that have access to such data and insights can share them, enabling other players to understand their biodiversity risks and opportunities and to develop technologies and approaches to address them. For example, the WWF in partnership with BCG developed an early warning system to predict and prevent illegal deforestation. Similarly, better data on soil health or geological structures can help reduce biodiversity degradation caused during resource extraction and cultivation. And accurate information on the value of ecosystem services within a certain region can guide investments by local governments and stakeholders in its preservation and restoration.

- **Raise awareness and advocate positive change.** Although public awareness of the threats to biodiversity is growing, many stakeholders still lack a thorough understanding of the need for change. That's why companies should drive collective action to raise awareness and increase demand for biodiversity-safe products among consumers, and to catalyze biodiversity-positive changes in product value chains among industry and value chain peers. Companies from different industries have united in the UK Plastics Pact to raise awareness about the environmental impact of plastic waste and to promote a more circular plastic economy. Moreover, in some cases, regulations—such as subsidies that favor larger agricultural operations or exacting aesthetic standards for fruits and vegetables—can limit the ability of companies to adopt biodiversity-positive practices. Companies should advocate for regulatory changes to ensure that biodiversity-safe business practices do not cause companies to incur additional costs. For example, the Business for Nature initiative, a coalition of businesses and NGOs, is pushing post-COVID-19 policymaking that ties subsidies to biodiversity-safe practices.

- **Fund protection and restoration efforts.** Companies that believe they are not in a position to conserve and enhance biodiversity in local ecosystems directly should consider funding external protection and restoration efforts. Restoration measures are especially important in ecosystems with rich biodiversity and a high potential for carbon sequestration. The NGO Conservation International has established several funds—supported in part by companies—that invest in conservation and restoration of valuable ecosystems in areas such as Sub-Saharan Africa, the Amazon, and the Mekong region. Moreover, several platforms help companies match their priorities with suitable projects, including those provided by the Global Environment Facility and by the UN's REDD+ program. Some of those projects can enable their corporate backers to earn carbon credits. Extended to other ecosystem services, such schemes could be powerful drivers of restoration.

The most forward-looking companies today combine advanced biodiversity support programs such as stewardship with ambitious moves in footprint management and innovation to reach their strategic objectives. Consider South African retailer Woolworths' Farming for the Future Program. Through this initiative, the company works with and sets standards for suppliers with the goal of reducing their use of chemicals and their water consumption. The company is also leveraging innovation, including in its partnership with Aerobotics, to reduce the negative biodiversity impact of farming activities in its value chain. And it is working with WWF-South Africa, WWF-UK, the Alliance for Water Stewardship, and M&S to reduce water-related environmental issues in the stone fruit supply chain.

A Call to Action

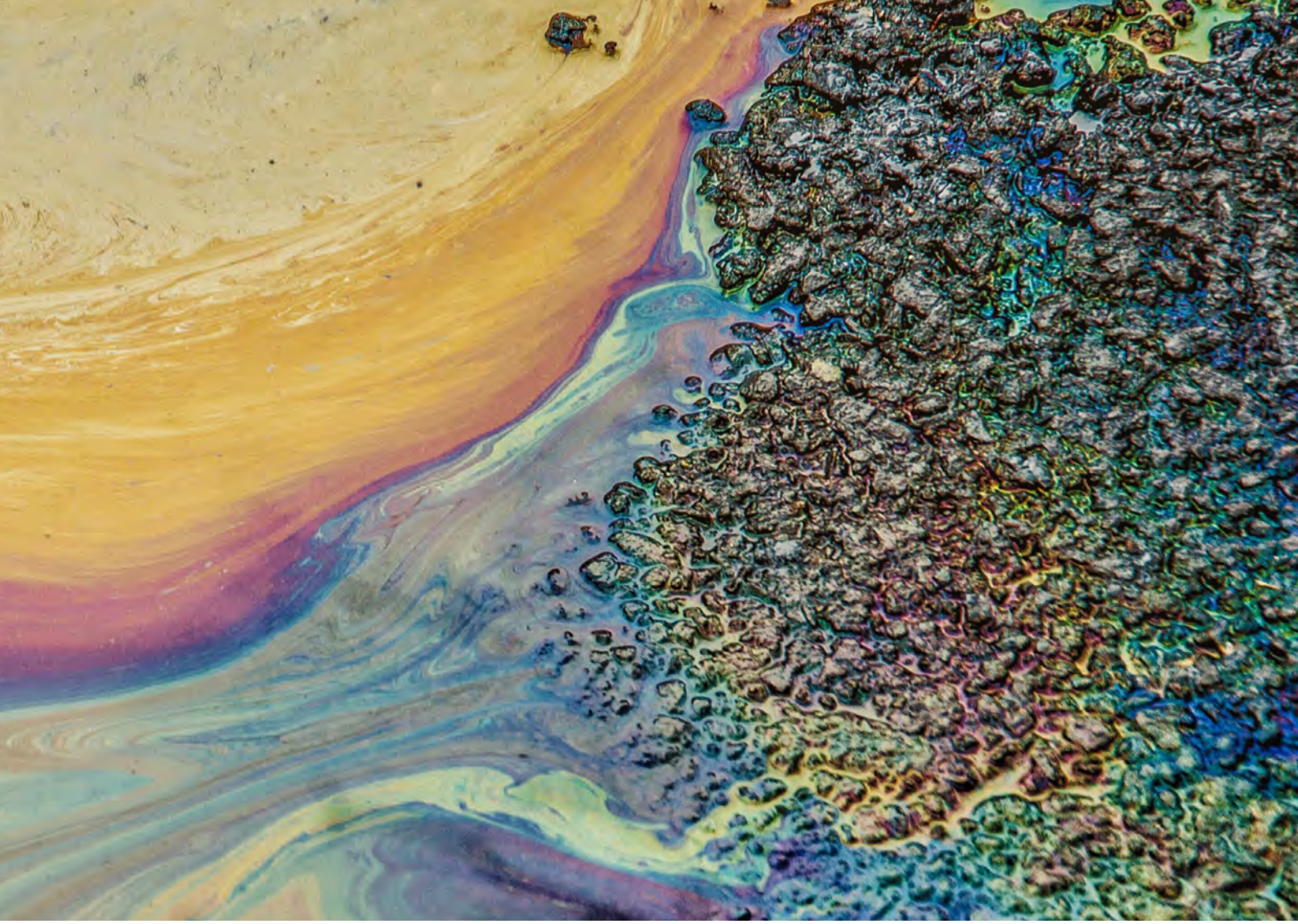
Biodiversity is vital to the health and functioning of our planet. But it is declining at a staggering rate, largely as a result of human activities. The repercussions of continued ecosystem decline may include the disruption of major supply chains, such as for food or clothing, and economy-wide impacts, such as those resulting from natural disasters that cause critical infrastructure to collapse. Already, biodiversity loss is reducing annual global GDP by $5 trillion.

Fundamental changes are necessary to reverse biodiversity loss and preserve the ecosystem services that provide the foundations of our economic systems and societal well-being. Business must play a central role in accomplishing that mission, owing to its control over many activities that destroy biodiversity and its ability to drive change and innovation at scale. To begin building a biodiversity-positive business, company leaders should ask themselves the following questions:

- What risks and opportunities does biodiversity loss pose for my company?
- In what ways does my company create or contribute to pressures on biodiversity?
- Which pressures on biodiversity does my company control, and where can my company's capabilities create positive change?
- How can I ensure that my company's initiatives align with science and deliver measurable progress?
- What actions are most suitable for my company's business model?

Fortunately, companies that move ahead with an ambitious biodiversity agenda today do not face a prisoner's dilemma. Those that take action will not only mitigate major risks, but also seize new opportunities, including tapping into growing markets, delivering on growing consumer and investor expectations, and boosting their attractiveness as employers. And although some actions outlined in this report require investment that may take several years to pay off, many companies can make moves today that yield immediate benefits for them and for vital ecosystems around the world.

Acting on biodiversity loss is not a choice but an imperative. Sooner or later, all stakeholders will need to act. Companies that move first and take action in a collaborative way will build sustainable, competitive advantage and contribute significantly to preserving the natural balance of life on Earth.



Appendix

Valuation of Ecosystem Services

We have estimated the global annual value of ecosystem services, based on the Ecosystem Service Value Database, which was developed between 2007 and 2014 by research teams led by Robert Costanza and Rudolf de Groot for the international initiative The Economics of Ecosystems and Biodiversity (TEEB). Ecosystem service value is defined as the contribution of the assets of nature at a specific point in time.

To make the value of ecosystem services comparable to current economic output, we conducted three major analytical steps.

1. We adjusted all ecosystem service values for inflation to 2019 dollars, using the World Bank's average global inflation rate.

2. We developed updated estimates for provisioning services from forests, croplands, grasslands, and the ocean on the basis of current market sizes. We took the total market sizes for different product groups—such as agricultural outputs—and applied EBITDA margins to them in order to obtain the actual value of the raw materials that each of these ecosystems provides.

3. We recalculated the values for the climate regulation service using three CO2 prices: $50 per ton, $80 per ton, and $120 per ton, which represent currently accepted scientific estimates of the social cost of carbon (SCC) at different social discount rates. Those inputs yielded a lower estimate of $150 trillion, a midrange estimate of $160 trillion, and an upper estimate of $170 trillion for total ecosystem services value. This approach results in a 10% deviation in overall ecosystem services value between this report and the BCG and NABU report *The Biodiversity Imperative for Business*, which focused on stakeholders in Germany and therefore used a price of roughly $200 per ton, as suggested by the German Environmental Agency.

Table 1 summarizes the assumptions we used in these steps. Importantly, our calculation does not account for any losses in ecosystem service value incurred since 2011, when the TEEB initiative conducted its last measurement. Moreover, because the stated value is a static representation of the latest measurements and assumptions, it does not account for fluctuations in ecosystem functionality and market dynamics, which have a continually varying impact on the economic worth of biodiversity.

It is important to bear some limitations in mind when conducting a monetary assessment of ecosystem services and biodiversity. First, economic valuation must be interpreted with caution, as assessments of monetary value cover only anthropogenic benefits of biodiversity. Second, the true value of ecosystem services will undoubtedly deviate from the value calculated here, for the following reasons:

- Many aspects of those services—such as the inherent value of habitat provision or spiritual benefits—are difficult to evaluate.
- There is no proxy for evaluating the systemic benefits of interactions between global ecosystems and their species—that is, natural cycles.
- Ecosystem services are not negotiable and not substitutable.

To derive the already-lost value of annual ecosystem services, we assumed that the share of 3% to 15% of lost ecosystem service value has remained the same as in Costanza et al.'s 2014 study, "Changes in the global value of ecosystem services." Adjusting their original range of $4 trillion to $20 trillion to present-day terms yielded an estimate of about $5 trillion to $25 trillion in value that the global economy already forfeits each year. Since measurements of ecosystem area and ecosystem services at local level were most recently conducted in 2011 and biodiversity has continued to degrade since then, this value should be considered a lower bound.

Appendix Table 1 - Approaches for Valuation of Ecosystem Services

Category	Type	Valuation approach	Value	Assumptions/comments	Source
Unit values	International dollars	Inflation adjustment of 2007 dollar values to 2019 dollar values by considering average inflation rate	3.4%	• Based on Costanza, normed "2007 international $/year" values • Average global inflation rate from 2007–2019	1,2
Climate regulation	Open oceans, forests	Average carbon sequestration rate (tCO_2/ha)	Per ecosystem	• Temperate forests 1.5 tC/ha • Tropical forests 10 tC/ha • Converted to tCO_2 with conversion factor of 3.67 • Oceans based on results from BCG study on oceans' ability to absorb CO_2 (in tCO_2/ha)	3,4
		CO_2 price accounting for externality costs ($/$tCO_2$)	80 [50–120]	• Range of $50/t to $120/t for CO_2 prices that internalize the external costs of emissions on the basis of current literature • Price of $80 chosen as BCG baseline value	5
Provision of raw materials	Tropical, temperate, and boreal forests	Annual revenues from global wood, fiber, and nonwood forestry products ($)	Per forest type	• Global revenues per forest and product type	6
		EBITDA margin (%)	Average 13%	• Discounting of revenues necessary to reach the value of raw materials provided by forests	6

Appendix Table 1 - Approaches for Valuation of Ecosystem Services

Continued...

Category	Type	Valuation approach	Value	Assumptions/comments	Source
Provision of food	Cropland	Total global agricultural revenues ($trillions)	2.6	• Gross production value of agriculture minus value from livestock production, as we assume that livestock production is not an inherent ecosystem service • FAO $2.4 trillion value in 2016 dollars, inflation-adjusted to 2019 dollars	7,2
		EBITDA margin (%)	Average 25%	• With EBITDA margins of global agriculture/farming sectors at 7%, we assume a total share of 25% to reflect that inputs such as seeds and fertilizer are also based on natural products • Share of natural inputs in agricultural products is high and fluctuates strongly	
	Grasslands	Total food provisioning ($)	0	• We assume that grasslands do not offer additional food provisioning (other than as considered in croplands) • Livestock production is not considered as an ecosystem service	
	Open oceans, coasts	Total global revenues from marine food production ($trillions)	0.43	• Sales value of marine fish (captured and aquaculture) in 2016, inflation-adjusted to 2019 dollars	8
		EBITDA margin (%)	Average 25%	• Discounting of revenues necessary to reach the actual value of raw materials offered by each ecosystem • Assuming EBITDA margin from the agricultural sector to be about the same for fisheries	
Provision of genetic and medical resources	Open oceans, coasts	Adaptation of Costanza revenue values to net value	0.43	• Values from Costanza include net worth of products and an option valuation of potential future revenues	1
		EBITDA margin (%)	Average 25%	• EBITDA margin of agricultural products, global aggregated average of last three years	6
Air purification	Forests	Based on BCG forest paper approach: rate of air pollutant removal (t/ha) × Costs per ton of pollutant ($/t) × Recreational forest area (million ha)		• Forests reduce pollution costs by absorbing odors and pollutant gases and filtering particles from the air • Including PM2.5, NO_2, SO_2, O_3 • Air purification service occurs mostly in areas close to human settlements, which are recreational forest areas.	6

Sources: BCG analysis, based on:

[1]Robert Costanza et al., "Changes in the global value of ecosystem services." Global Environmental Change 26: 152–58 (2014).

[2]World Bank data, https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG. Accessed May 2020.

[3]David Pimentel, et al., "Environmental and economic benefits of biodiversity." College of Agriculture and Life Sciences, Cornell University, Ithaca, NY, mimeo (1996).

[4]O. Hoegh-Guldberg et al., "Reviving the Oceans Economy: The Case for Action – 2015." WWF International, Gland, Switzerland (2015).

[5]William Nordhaus, "Revisiting the social cost of carbon", Proceedings of the National Academy of Sciences of the United States of America 114: 1518–23 (2017).

[6]Kappen et al., "The Staggering Value of Forests—and How to Save Them," BCG (2020).

[7]FAOSTAT-Database, http://www.fao.org/faostat/en/#data.

[8]UN FAO, "State of Fisheries and Aquaculture," http://www.fao.org/state-of-fisheries-aquaculture (2020).

Estimation of Pressures from Economic Activities

Since biodiversity is locally distinct, existing scientific studies focus on the extent to which different economic activities contribute to the decline of certain ecosystems, such as forests. We used these studies as the basis for our analyses, deriving proxies that enabled us to aggregate the effects on a global level from the best available data.

In the analysis shown in Exhibit 5 in chapter 2, we examine the shares of major economic activity groups (farming, forestry, and so on) in total pressure on biodiversity. Our analysis involves three steps and several assumptions:

1. Determine the contribution of economic activities to the major pressures on four biodiversity components: overall wildlife, marine ecosystems, terrestrial ecosystems, and freshwater ecosystems. We assigned each of these components a proxy indicator of pressure on biodiversity. Table 2 shows the indicator applied per ecosystem type and lists the dominant activities responsible for these pressures. We then aggregated the results under the assumption of equal weighting of the four components.

2. Calibrate the output by the implied distribution of economic activities as the root causes underlying the five biggest pressures on biodiversity, as enumerated in Exhibit 3 (land-use and sea-use change; direct overexploitation; climate change; pollution of soil, water, and air; and spread of invasive species). We accomplished this by comparing the distribution resulting from step 1 with literature on the contribution of economic activities to the five pressures (such as IPCC data on the shares of economic activities in climate change and studies on the relative contributions of economic activities to pollution). We then validated the resulting assessment with experts from science, conservation work, and industry.

3. Calibrate the results by comparing the implied overall split between the big five pressures to the shares mentioned in IPBES's 2019 "Global Assessment Report on Biodiversity and Ecosystem Services," which features the area-based split for terrestrial, freshwater, and marine ecosystems.

Estimation of Value Chains' Shares in Pressures from Economic Activities

To determine the shares of different value chains in pressures on biodiversity, we first grouped various consumer end products and services into a few major clusters according to the resources and conversion activities underlying them. We obtained four value chains with a particular link to activities degrading biodiversity—food and beverages; clothing and related goods, such as luxury accessories; energy, including power and fuels; and infrastructure and mobility, including housing, public infrastructure, and vehicles—along with others that had more selective interactions with biodiversity, such as cosmetics, household goods, and consumer electronics.

Next, we attributed the biodiversity pressures enacted by different economic activities, as shown in Exhibit 5, to each value chain. We then split up the impact of each economic activity across the value chains and calibrated the results thereafter. (See Table 3.)

Some economic activities—such as fishing, which is part of the food value chain—exclusively contribute to one particular value chain. For other economic activities, we used proxies such as different products' use of outputs from the activity (for example, metals, nonmetals, and fossil fuels for mining and extraction) or different products' need for land (for farming) or generation of plastic waste (for consumer waste) to allocate their biodiversity impact across value chains.

Our adaptive approach enabled us to use best available data and approximate actual biodiversity impact as closely as possible. Some estimation methods use contributions to single pressures (such as GHG emissions) as a proxy for full biodiversity impact, and others do not account for localized factors (such as deforestation, which may have widely varying severe impacts, depending on its location). Therefore, we also recalibrated the estimated share of each value chain in accordance with literature and experts from science, conservation work, and industry to ensure the accuracy of our results.

Appendix Table 2 - Approaches for Estimation of Sector Shares of Biodiversity Pressure

Biodiversity component	Proxy indicators of pressure on biodiversity	Major contributors	Source
Terrestrial ecosystems	• Contribution to deforestation (50%) • Contribution to forest and soil degradation (50%)	• Farming (~40%) • Forestry (~20%) • Infrastructure expansion (~15%) • Mining (~5%) • Power generation (~5%) • Transportation (~5%) • Other, including consumer activities and subsistence (~10%)	1, 2, 3, 4, 5
Freshwater ecosystems	• Overall threats to freshwater habitats, based on Living Planet Index • Contribution to threats (habitat loss, overexploitation, climate change, pollution)	• Farming (~30%) • Fishing, including aquaculture (~30%) • Power generation (~10%) • Mining (~10%) • Industry (~10%) • Other, including consumer activities and infrastructure expansion (~10%)	6, 7, 8, 9, 10
Marine ecosystems	• Overall threats to marine habitats, based on Living Planet Index • Contribution to threats (habitat loss, overexploitation, climate change, pollution)	• Fishing incl. aquaculture (~70%) • Farming (~10%) • Consumer activities (~5%) • Transportation (~5%) • Other, including power generation, industry, and infrastructure expansion (~10%)	6, 7, 8, 10, 11
Wildlife overall	• Species affected by different threats, based on IUCN Red List	• Farming (~30%) • Forestry (~15%) • Infrastructure expansion (~15%) • Industry (~15%) • Fishing, including aquaculture (~10%) • Consumer activities (~5%) • Other, including transportation and power generation (~10%)	6, 8, 12

Sources: BCG analysis, based on:

[1]Noriko Hosonuma et al., "An assessment of deforestation and forest degradation drivers in developing countries." Environmental Research Letters 7.4 (2012): 044009.

[2]IPCC, 2019: "Climate Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems."

[3]Panagos et al., "Cost of agricultural productivity loss due to soil erosion in the European Union: From direct cost evaluation approaches to the use of macroeconomic models." Land Degradation & Development (2017).

[4]Pearson et al., "Greenhouse gas emissions from tropical forest degradation: an underestimated source." Carbon Balance and Management (2017).

[5]UNCCD, "The Global Land Outlook, first edition" (2017).

[6]IPCC data on national emissions (2014), accessed via European Energy Agency: https://www.eea.europa.eu/data-and-maps/daviz/change-of-co2-eq-emissions-2#tab-dashboard-01.

[7]IUCN and European Commission, "European Red List of Habitats" (2016).

[8]IUCN Red List derived from Maxwell at al., "Biodiversity: The ravages of guns, nets and bulldozers." Nature (2016).

[9]UN FAO, "Global Capture Production database updated to 2015" (2015), and "An Overview of Recently Published Global Aquaculture Statistics" (2016).

[10]WWF, 2018: "Living Planet Report 2018: Aiming Higher."

[11]UN FAO, "Fishery and Aquaculture Statistics 2014 yearbook" (2014).

[12]IUCN current Red List, https://www.iucnredlist.org/. Accessed June 2020.

Appendix Table 3 - Approaches for Estimation of Value Chain Shares of Biodiversity Pressures

Economic activities	Value chains					Assumptions/proxies used	Source
	Food	Infrastructure	Fashion	Energy	Other		
Farming	~85%	0%	~10%	~5%	0%	Based on shares of agricultural land use	1, 2
Fishing	100%	0%	0%	0%	0%	Allocation is given by value chain definition	
Forestry	0%	~85%	0%	<5%	~12%	Based on global composition and use of wood-based products	3
Mining and extraction	<5%	~35%	~10%	~45%	~5%	Based on usage of different material extractions (e.g., metals, fossil fuels) and their respective environmental impact	4
Industrial production	~5%	~55%	~5%	~15%	~20%	Extrapolated on the basis of share of GHG emissions of different kinds of industrial production (e.g., chemicals, iron and steel)	5, 6, 7
Power generation	0%	0%	0%	100%	0%	Allocation is given by value chain definition	
Infrastructure expansion	0%	100%	0%	0%	0%	Allocation is given by value chain definition	
Transportation	~15%	~45%	~5%	~10%	~20%	Extrapolated on the basis of share of GHG emissions of different goods being transported (passenger transport not included)	8, 9
Private consumption and subsistence (small-scale farming, fishing, etc.)	~65%	~5%	~20%	~5%	~5%	Extrapolated on the basis of share of plastic waste generated by different sectors	10, 11
Other (retail, service institutions, poaching, etc.)	~20%	0%	~30%	0%	~50%	Estimated from different literature	2, 7

Sources: BCG analysis, based on:

[1]Our World in Data, 2020, https://ourworldindata.org/land-use/. Accessed October 14, 2020.

[2]Deviah Aiama et al., "Biodiversity risks and opportunities in the apparel sector." International Union for Conservation of Nature: Gland, Switzerland (2016).

[3]"Forest Product Statistics." Food and Agriculture Organization of the United Nations, 2020, http://www.fao.org/forestry/statistics/80938/en/. Accessed October 14, 2020.

[4]Bruno Oberle et al., "Global resources outlook 2019: natural resources for the future we want." (2019).

[5]IEA CO2 Emissions from Fuel Combustion Statistics. International Energy Agency, 2019. Accessed 14 Oct 2020.

[6]UNFCCC, 2020, https://unfccc.int/process-and-meetings/transparency-and-reporting/greenhouse-gas-data/ghg-data-unfccc/ghg-data-from-unfccc. Accessed October 14, 2020.

[7]BCG Center for Climate Action.

[8]Climate Change 2014: Mitigation of Climate Change: Working Group III Contribution to the IPCC Fifth Assessment Report, Cambridge University Press, 2015, pp. 599–670.

[9]Eurostat, 2020, https://ec.europa.eu/eurostat/web/transport/data/database. Accessed October 14, 2020.

[10]Noriko Hosonuma et al., "An assessment of deforestation and forest degradation drivers in developing countries." Environmental Research Letters 7.4 (2012): 044009.

[11]"Global Plastic Waste Generation Share By Sector 2018". Statista, 2018, https://www.statista.com/statistics/1166582/global-plastic-waste-generation-by-sector/. Accessed October 14, 2020.

Biodiversity Measurement Tools

A host of biodiversity measurement tools can help companies understand and address their biodiversity footprint. These tools typically track a broad range of biodiversity data points and include specific ways of aggregating that data to provide actionable insights for companies. Most tools serve one of three major purposes: understanding a company's overall footprint, assessing risks and opportunities related to biodiversity decline, or evaluating the state of nature as a basis for selecting local initiatives. (See the exhibit.)

Biodiversity Measurement Tools Serve Different Purposes

Tools for understanding and communicating **total biodiversity footprint**

Requirement

Tools that help users measure and benchmark the global biodiversity footprint, identify key issues, track overall progress, and communicate it to stakeholders

Selected tools

- **Global Biodiversity Score**[1]
  Aggregates the contributions of different pressures into a single biodiversity score for simple communication and tracking
- **Biodiversity Impact Metric**
  Shows the biodiversity impact of products on the basis of land use
- **Product Biodiversity Footprint**
  Shows the biodiversity impact of products in terms of their contributions to the five major pressures

Tools for identifying **exposure to biodiversity decline**

Requirement

Tools to assess risks to the company's business arising from biodiversity decline in specific ecosystems—for example, through loss of resources or ecosystem services

Selected tools

- **InVEST**
  Maps and values the goods and services received from nature
- **ENCORE**
  Explores natural capital risks and identifies impacts and dependencies on ecosystem services
- **WWF Water Risk Filter**
  Identifies water-related risks facing the company's operations and suppliers

Tools for developing **initiatives** and **tracking local impact**

Requirement

Tools that accurately display the health and needs of local ecosystems and allow the company to track the progress of its initiatives and their eventual impact on ecosystem health

Selected tools

- **Integrated Biodiversity Assessment Tool**[2]
  Details biodiversity development and risks in a particular region
- **Impact World+**
  Shows the per-region life cycle impact of different products
- **Biodiversity Impact Metric**
  Tracks the biodiversity impact of products throughout the supply chain
- **Biodiversity Impact Calculator**
  Tracks local biodiversity impact through land use

Sources: Science-based Targets Network; BCG research.

[1]Builds on the Mean Species Abundancy metric.

[2]Builds on the IUCN Red List.

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