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Biodiversity: Concepts, themes and challenges

A Center for Sustainability publication

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The Center for Sustainability (CfS) is a pillar of the Credit Suisse Research Institute (CSRI), our in-house think tank, which studies long-term economic developments that have a global impact on the financial services industry and beyond. The CfS aims to provide our clients and stakeholders with a deeper understanding of emerging sustainability topics as we bridge the perspectives of sustainability experts from across Credit Suisse to confront the challenges and opportunities faced by our planet and society. Also collaborating with leading external sustainability experts, we strive to elevate CfS content and engage more productively in the broader concept of environmental, social and governance themes.

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Introduction

Welcome to the second report produced by the Credit Suisse Center for Sustainability (CfS).

The CfS is part of the Credit Suisse Research Institute, our in-house think tank, which studies long-term developments that have a global impact on the world of finance and societies more broadly. The focus of the CfS is on producing thought leadership analysis on key sustainability-related themes. It does so by drawing on the insights from senior Credit Suisse and external experts. These themes form an important part of the global dialogue that is needed in our view to help achieve a more sustainable future.

In this report, we provide a high-level examination of the broad developments and opportunities associated with biodiversity. A healthy presence and variability among living organisms and ecosystems sustains all life, water and food. The economic impact of this is highly significant as over half of the world's economic output is moderately or highly dependent on nature. Finally, healthy biodiversity also helps to reduce greenhouse gas emissions and limit climate change.

Successfully addressing the various biodiversity-related issues as outlined in this report requires a strong institutional response. With the upcoming United Nations Biodiversity Conference (COP 15) in December this year, we expect the focus on regulating, standardizing and reporting of nature-based risk to increase. This report highlights what has been achieved in this regard so far and, even more importantly, the steps that have yet to be taken.

In trying to understand the nuances, roles and challenges related to biodiversity, I trust that you will find this report an informative contribution.

Emma Crystal
Chief Sustainability Officer, Credit Suisse

Why biodiversity matters

In some of our previous work on sustainability, we have focused on a range of topics related to natural capital (the world's stock of natural assets including geology, soil, air, water and all living organisms) including the food system, deforestation, reforestation and voluntary carbon markets. In this publication, we explore the trends and key issues associated with biodiversity, or the variability among living organisms and ecosystems. We see it as one of the key issues for investors given that human civilization is ultimately dependent on a healthy natural environment and biodiversity.

A healthy biodiversity maintains ecosystems that in turn clean the water, purify the air, maintain the soil, regulate the climate, recycle nutrients and provide food. Biodiversity is both the foundation of our economy and the essential natural support system for life on Earth. Additional reasons supporting our view on the relevance of biodiversity include:

- Our food system depends on a healthy biodiversity: The food system is built on nature, both in terms of land, but also in terms of the variety of different species. For example, we rely on pollinators for over 75% of our global food crop types (Aizen et al., 2019). Regrettably, due to the overuse of pesticides, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) estimates that USD 235–577 billion in the annual value of global crop output is now at risk due to pollinator loss.
- Biodiversity provides essential raw materials for medicines: Historically, over 50% of commercially available drugs were developed using bioactive compounds extracted (or patterned) from non-human species (Alves and Rosa 2007). Some of these include the single most effective agent for inducing remission in acute myelocytic leukemia, and exenatide, a synthetic version of a compound found in the saliva of the Gila monster, which is used by as many as two million people with type 2 diabetes.
- Tipping points and climate change: According to Meyer et al., 2022, even if global temperatures start to decrease after peaking this century due to climate change, biodiversity risks are likely to persist for a long time. Even if we collectively manage to reverse global warming before species are irreversibly lost, the ecological disruption caused by unsafe temperatures could persist for an additional half century or more.
- The Stern Review on the Economics of Climate Change (2006) described climate change as the largest-ever market failure. The Dasgupta Review on The Economics of Biodiversity (2021) called the biodiversity crisis a "deep-rooted, widespread institutional failure" and defines our institutions as "unfit to manage the externalities." The Dasgupta Review questions whether biodiversity loss is the next market failure or simply a failure of contemporary conceptions.

The IPBES 2019 global assessment showed that a business-as-usual approach is unacceptable given that at least 40% of the world's economy and 80% of the needs of the developing countries are derived from biological resources. According to estimates from the World Economic Forum, USD 44 trillion of economic value generation – over half the world's total gross domestic product (GDP) – is moderately or highly dependent on nature[1].

The three sectors with the greatest exposure to nature generate close to USD 8 trillion of gross value added, i.e. construction (USD 4 trillion), agriculture (USD 2.5 trillion) and food and beverages (USD 1.4 trillion). The Economics of Ecosystems and Biodiversity (TEEB) initiative estimates that global sustainable business opportunities from investing in natural resources could be worth USD 2–6 trillion by 2050[2]. However, if biodiversity loss continues at its current rate, we could lose USD 338 billion per year.

1. https://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf
2. https://www.teebweb.org/wp-content/uploads/Study%20and%20Reports/Reports/Business%20and%20Enterprise/Executive%20Summary/Business%20Executive%20Summary_English.pdf


Photo: Credit Suisse

The state of biodiversity

Biodiversity is being increasingly threatened, with up to one million species at risk of extinction (IPBES). The reasons include climate change, pollution and deforestation – all of which are ultimately driven by overconsumption and unsustainable production patterns. Climate change matters for biodiversity. For example, it lowers nature's ability to capture anthropogenic CO2 emissions, whereby each degree of warming reduces the number of fish by 5%–7% (IPCC).

Earth is exceeding its biocapacity

Biodiversity is the variability among living organisms and ecosystems. The United Nations Convention on Biological Diversity (CBD) defines biodiversity as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems. Scientists have estimated there are over eight million species on Earth.

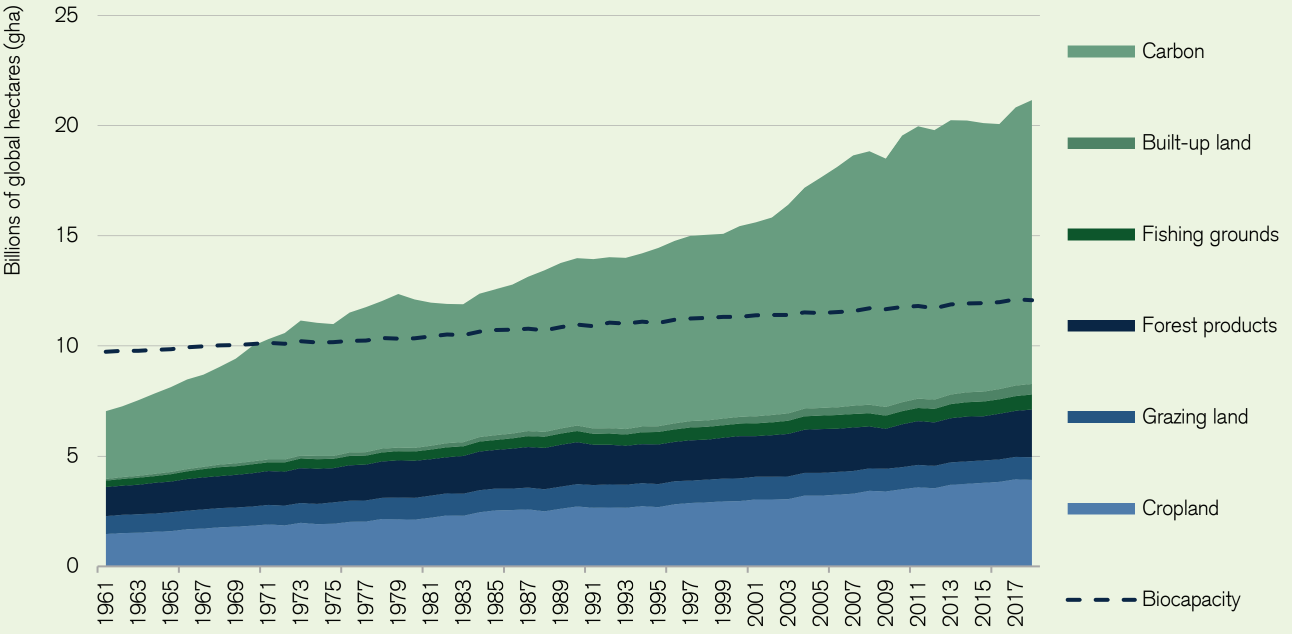
> "Human activity has changed the natural process of extinction and evolution

Biodiversity is an essential characteristic of nature that secures its survival. It enables ecosystem assets to be productive, resilient and able to adapt to change. Biodiversity operates at a genetic, species, habitat and ecosystem level, and is critical to maintaining the quality, resilience and quantity of ecosystem assets and services upon which business and society rely. The greatest levels of biodiversity of terrestrial vertebrates are found at the equator.

Earth is exceeding its biocapacity, i.e. the ability of our planet's ecosystems to regenerate. This ecological balance sheet allows us to contrast biocapacity with all the human demands that compete for biologically productive areas. Through changes in technology and land management practices, global biocapacity has increased by about 28% over the past 60 years (ZSL). However, humanity's ecological footprint has increased by about 173% over the same period and now exceeds the planet's biocapacity by 56% (see **Figure 1**). This means that human enterprise currently demands 1.56 times biocapacity more than the amount that Earth can regenerate.

Up to one million species are threatened: the IPBES estimates that up to one million species could become extinct, many within decades. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species shows cycads, amphibians, coral reefs, sharks and rays to be particularly at risk. The global biomass of

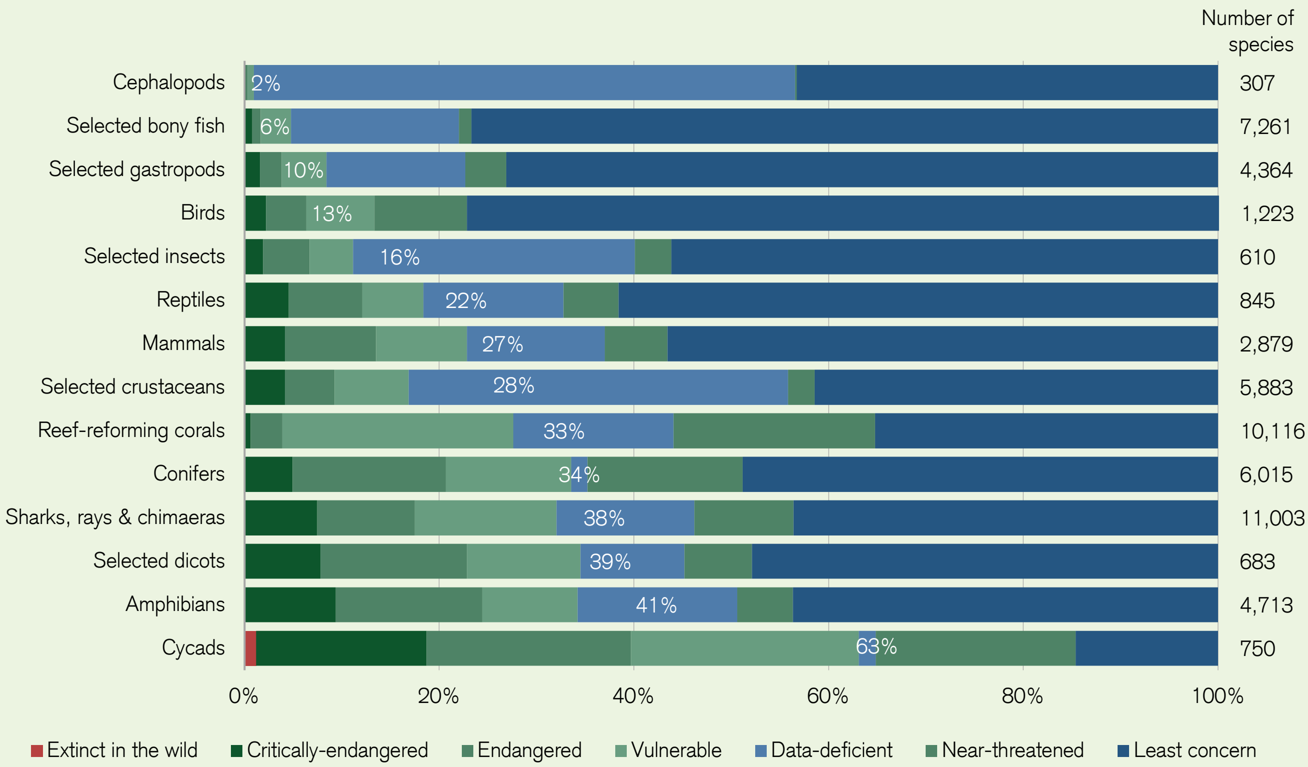
Figure 1: Earth's biocapacity vs. humanity's ecological footprint



Source: ZSL, Credit Suisse

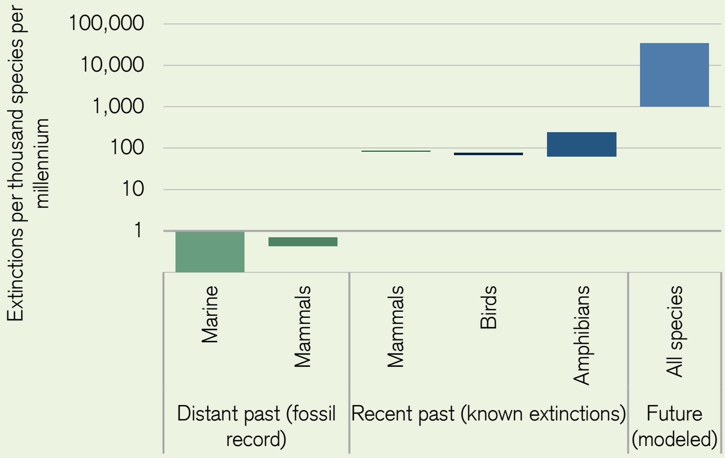
Figure 2: 28% of all species assessed by IUCN are threatened

Percentage on chart indicates best estimate for proportion of species at risk



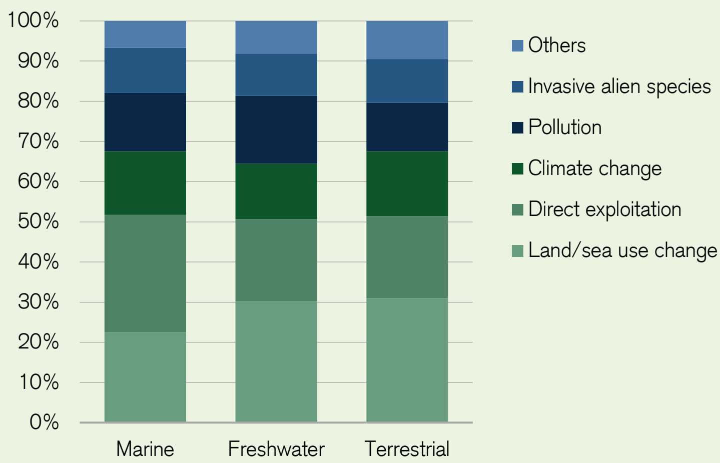
Source: IUCN, Credit Suisse

Figure 3: MEA extinction rate comparison



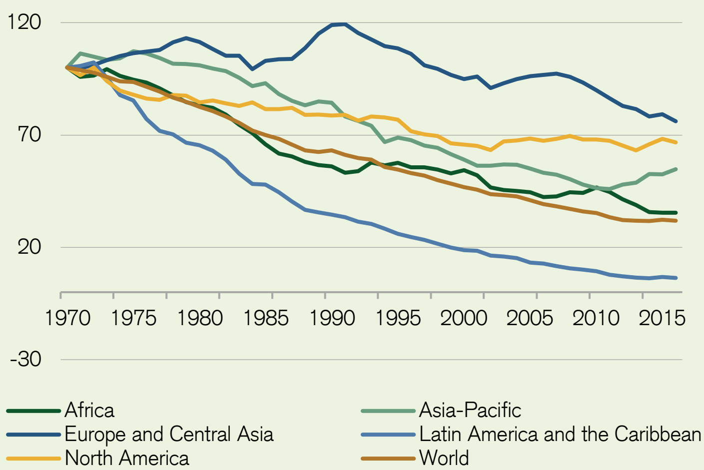
Source: Millennium Ecosystem Assessment, Credit Suisse

Figure 4: Direct causes of decline



Source: IPBES, Credit Suisse

Figure 5: Changes in biodiversity loss from 1970 to 2016



Source: WWF/ZSL, Credit Suisse

wild mammals has fallen by 82% and natural ecosystems have declined by 47% on average, relative to their earliest estimated natural states (**Figure 2**).

Extinction is a natural process, but humans have undoubtedly accelerated it, with species dying out at 100–1,000 times the natural rate (**Figure 3**). In the past hundred years, biodiversity around the world has decreased dramatically. Many species have become extinct. Some species naturally die out, while new species evolve through competition. But human activity has changed the natural process of extinction and evolution. Accordingly, the Millennium Ecosystem Assessment (MEA) estimates that species are dying out at 1,000 times the natural rate. If left unchecked, this rate could increase to 10,000 times (**Figure 3**).

What is causing biodiversity loss?

Direct and indirect drivers of change have accelerated over the past 50 years. The rate of global change in nature is unprecedented in human history. According to the United Nations, the direct drivers of change in nature with the largest global impact have been (in order of impact) changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasive alien species (see **Figure 4**). The biodiversity of terrestrial and freshwater ecosystems has been impacted most by land use change since 1970, followed by the direct exploitation of animals, plants and other organisms, mainly via harvesting, logging, hunting and fishing. In marine ecosystems, direct exploitation of organisms (mainly fishing) has had the largest relative impact, followed by sea-use change.

Overconsumption and unsustainable development

Patterns of overconsumption and unsustainable development are the underlying cause of biodiversity loss (IPBES). The direct drivers outlined above result from an array of underlying causes – the indirect drivers of change – which are underpinned by societal values and behaviors that include production and consumption patterns, human population dynamics, trade, technological innovations and governance. The rate of change in these drivers differs among regions and countries, resulting in differing biodiversity outcomes. The Living Planet Index (LPI) is a measure of the state of the world's biological diversity based on population trends of vertebrate species from terrestrial, freshwater and marine habitats. Globally, the population sizes of mammals, birds, fish, amphibians and reptiles have seen an alarming average drop of 68% between 1970 and 2016 (**Figure 5**). By region, the 94% decline in the LPI for Latin America and the Caribbean is the most striking. Europe and Central Asia saw a decline of 24%,

smaller than any other region, partly thanks to conservation efforts. However, the region has a high consumption footprint and exceeds its biocapacity by the largest amount.

Land-use change affects habitats – each year, ten million hectares of forest are destroyed. The United Nations Food and Agriculture Organization estimates that global deforestation between 2015 and 2020 was around ten million hectares (Mha) per year, having declined from 15 million in 2000 (**Figure 6**). While deforestation continues to decline, the rate of decline is slowing, going from a 33% decrease in 2000–10 to 27% in 2015–20. There are also signs of reversal in some regions such as the Brazilian Amazon. The rate of net forest loss (deforestation combined with forest expansion) was about 10% lower in 2010–20 than in the previous decade (4.7 mha p.a. compared with 5.2 mha p.a. in 2000–10), and the rate of net forest loss has fallen by about 40% since the annual average of 7.8 mha in the 1990s (**Figure 7**).

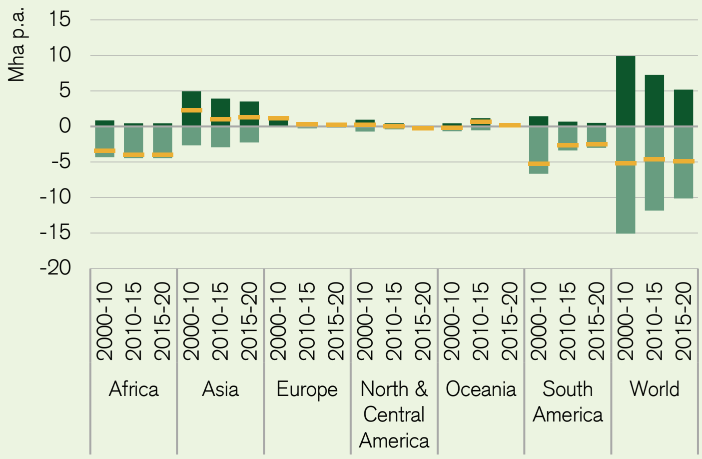
“

Each year, ten million hectares of forest are destroyed

This development is set to continue with rising population and no policy interventions: In our Treeprint report titled “Deforestation: outlook, solutions and the corporate response,” we show how the combination of income and population growth clearly implies that pressure to further increase agricultural production will remain high, which in turn would lead to further deforestation and thus biodiversity loss, unless action is taken by governments and corporates. We find that an additional 22 million square kilometers (km²) of agricultural land would be needed to produce the amount of food associated with this scenario. This is an increase of close to 50% from current levels and equates to 56% of the world’s current forest coverage (**Figure 8**).

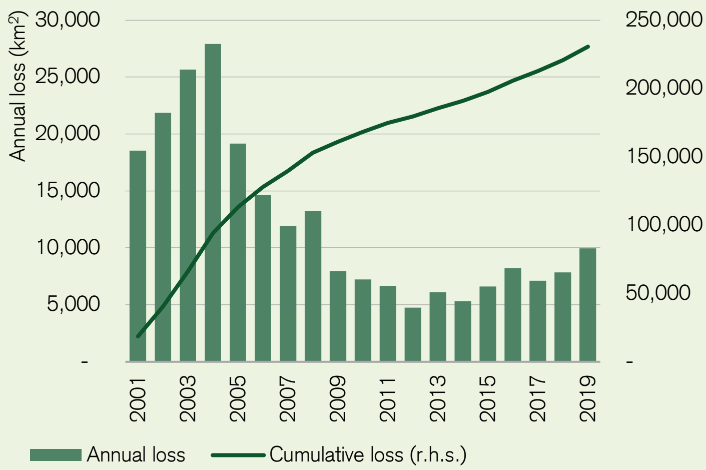
Human consumption has exploited species, pushing populations to the brink. Overexploitation to meet rising consumer demand is an issue in marine systems. Demand for fish as food and as

Figure 6: Rate of forest expansion and deforestation



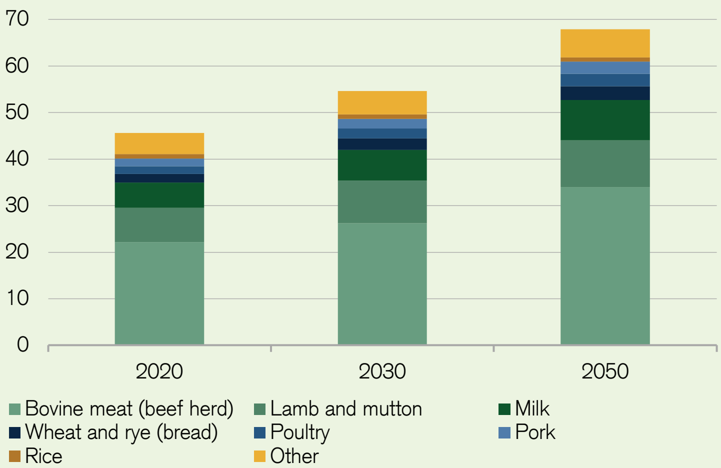
Source: Global Biodiversity Outlook, Credit Suisse

Figure 7: Deforestation in the Amazon slowly increasing



Source: Global Biodiversity Outlook, Credit Suisse

Figure 8: Total land demand to feed the global population in our convergence scenario has increased by 49% (m km²)



Source: Credit Suisse

feed for aquaculture is increasing, resulting in increased risk of a major, long-lasting collapse of regional marine fisheries. According to the Global Biodiversity Outlook, today just 66% of marine fish stocks are fished within biologically sustainable yields, falling from 90% in 1974 and 71% in 2010 to 65.8% in 2017. For marine species that are targeted by industrial fishing, the biomass of these species has reduced by 90%. Overall, about three-quarters (75%) of the world's commercial marine fisheries are either fully exploited (50%) or overexploited (25%).

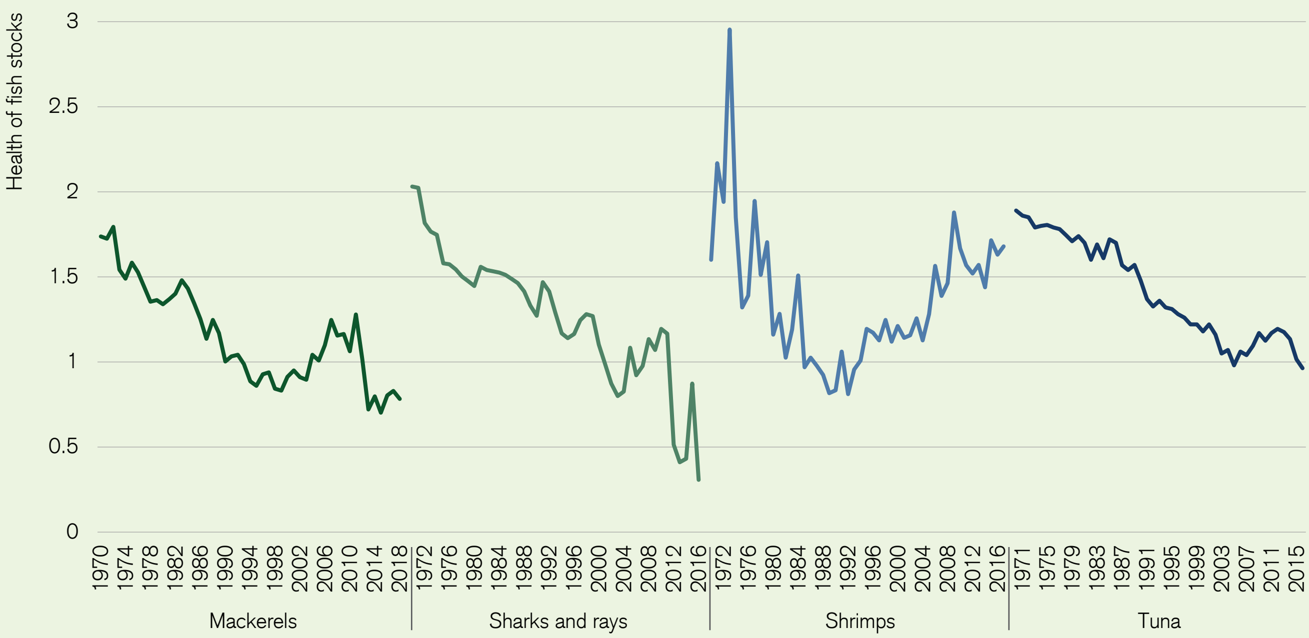
In **Figure 9**, we illustrate the impact of modern industrial fishing on the stocks of select species. The chart shows the total biomass of the species divided by the biomass at its maximum sustainable yield – which is the maximum amount of fish we can catch without a decline in fish populations. A value of one represents the sustainable catch without decreasing fish populations. Mackerel, sharks and rays are being fished unsustainably, while tuna fishing is approaching unsustainable levels. Shrimp fishing, however, appears not to have an impact on the stability of the population.

Polluted air, water and terrestrial habitats place pressure on species

According to the Global Biodiversity Outlook, it is estimated that over 80% of urban and industrial wastewater is released to freshwater systems without adequate treatment. Fertilizers used in crop production are drained into continental, coastal and marine water bodies at accelerating rates, with nitrogen fluxes (mainly as nitrate) rising four-fold to 20-fold in the last decade. Nutrients from fertilizers in continental water bodies flow into coastal waters, stimulating excessive plant growth and, in extreme conditions, hypoxia or oxygen-depleted "dead zones." These harmful algal blooms can affect primary and secondary productivity, which has greater implications throughout the food chain. For plastics, annual production grew 8.4% p.a. from 1950 to 2015, which is two times faster than GDP growth (Geyer et al., 2017). As much as 5% ends up in oceans due to inadequate waste management. Globally, 1.15–2.41 million tons of plastic currently flow from riverine systems into oceans every year (Lebreton et al., 2017).

Twenty percent of the Earth's surface is at risk of plant and animal invasions from alien species, particularly biodiversity hotspots (IPBES). Invasive alien species can affect the natural structure of ecosystems by interrupting trophic levels (the positions that organisms occupy in food webs) and disrupting existing interactions, introducing greater competition and stress. Invasive alien species (IAS) occurrences have doubled in the last 50 years and now threaten native species and ecosystem services (the benefits provided to humans by the natural environment and ecosystems). The cumulative number of alien species recorded is around 40 times greater in developed countries than in the least-developed countries, due in part to trade and population, but also improving

Figure 9: Mackerels, sharks and rays are fished at unsustainable levels, tuna at risk



Source: RAM Legacy Stock Assessment Database, Credit Suisse

Figure 10: Comparing the historic impact and current trends of each direct driver on different biomes or life zones

		Land/ sea change	Over-exploitation	Pollution	Invasive species	Climate change
Forest	Boreal	Low ↗	Low →	Moderate ↑	Low ↗	Low ↑
	Temperate	High ↘	Moderate →	Moderate ↑	Low ↑	Low ↑
	Tropical	Very high ↑	High ↗	Low ↑	Low ↑	Low ↑
Dryland	Temperature grassland	Very high ↗	Low →	Very high ↑	Moderate →	Low ↑
	Mediterranean	High ↗	Moderate →	Low ↑	High ↑	Low ↑
	Tropical grassland and savanna	High ↗	Very high →	Moderate ↑	Low ↑	Moderate ↑
	Desert	Low →	Low →	Low ↑	Moderate →	Moderate ↑
Inland water		Very high ↑	Moderate →	Very high ↑	High ↑	Low ↑
Coastal		Very high ↗	High ↗	Very high ↑	High ↗	Moderate ↑
Marine		Moderate ↑	Very high ↗	Low ↑	Low →	Low ↑
Island		High →	High →	Low ↑	Very high →	Low ↑
Mountain		High →	Low →	Low ↑	Low →	Moderate ↑
Polar		Low ↗	Moderate ↗	Moderate ↑	Low →	High ↑

Driver's impact on biodiversity over the last century: Low, Moderate, High, Very high

Driver's current trends: ↘ Decreasing impact; → Continuing impact; ↗ Increasing impact; ↑ Rapid increase in impact

Source: Millennium Ecosystem Assessment, Global Biodiversity Outlook, Credit Suisse

detection capacities. In addition, the rate of emerging alien species (those never encountered before) is high, with one quarter of first records only occurring in 2000–05.

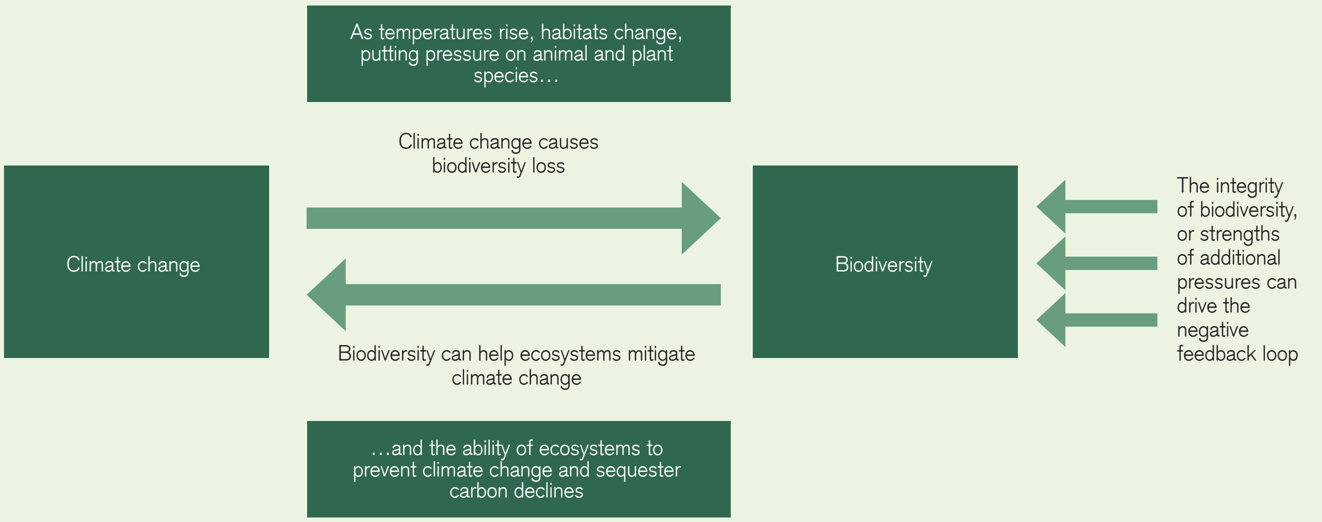
> “Globally, 1.15–2.41 million tons of plastic currently flow from riverine systems into oceans every year

How are climate and biodiversity inextricably linked?

The issues of climate and biodiversity are intrinsically connected through mechanistic links and feedback loops, sharing common anthropogenic drivers (human impacts on environmental change). Climate change exacerbates risks to biodiversity and habitats. At the same time, natural and managed ecosystems and their biodiversity play a key role in the flux of greenhouse gases and climate mitigation and adaptation. However, the extent of this relationship depends on the health of ecosystems. In **Figure 11**, we illustrate this relationship and how habitats change as climates worsen, putting pressure on species and ecosystems. In turn, this affects their ability to mitigate climate change and sequester carbon. Unabated, this continues in a negative feedback loop where failed mitigation leads to further increases in temperature, degrading ecosystems and causing biodiversity loss, thus further limiting the absorption of carbon. The latest report on climate change from the Intergovernmental Panel on Climate Change (IPCC)[1] concluded with “very high confidence” that climate change is impacting ecosystems on every continent and, in this section, we explore the complex linkages and feedback loops that exist.

1. https://www.ipcc.ch/report/ar6/wg2/downloads/outreach/IPCC_AR6_WGII_FactSheet_Biodiversity.pdf

Figure 11: Understanding the linkage between biodiversity, climate change and negative feedback loops



Source: Credit Suisse

With global temperatures already 1°C warmer, the effects are already visible. Human-induced warming was around 1°C ±0.2°C above pre-industrial levels in 2017, with increases of 0.2°C per decade. Evidence of long-term geophysical and biological changes due to warming is now clear in many parts of the world – such as in the retreat of mountain glaciers and the melting of sea and land ice affecting habitats, and physiological and morphological impacts on species like thermal stress and coral bleaching. The IPCC has found that half of all land species studied have shifted their geographic ranges in response to this development and half of the local populations of plants and animals have disappeared due to heatwaves. Warming is also affecting the seasons, e.g. with the earlier arrival of spring acting to change the phenology or life cycle events of species and affect overall primary productivity.

In 2016, we had the first recognized mammalian extinction caused by climate change: the Australian Bramble Cay melomys made headlines in 2016 when it was declared extinct following intensive surveys of the five-hectare coral cay in Australia's Torres Strait where the species lived. The cay is a small, low island composed of coral rubble and vegetation, and as sea levels have risen so have the high tides that wash over Bramble Cay. Over 90% of the vegetation of the cay has been lost since 2004 due to sea water inundation (Gynther et al., 2014). This reduction in food and cover due to climate change contributed to its extinction.

Future biodiversity outcomes are dependent on the global temperature: The second part of the IPCC AR6 report on impacts, adaptation and vulnerability emphasized that the level of biodiversity loss is also dependent on whether global temperature increases can be kept close to 1.5°C, or whether they exceed 2°C. In terms of wildfire risk, there is a 30% net increase in frequency and a 35% increase in area burned at 4°C warming. Under 2°C of warming, coral reefs are at risk of widespread decline due to the rising intensity and frequency of marine heatwaves.

Extinction risk increases with each degree of warming

In **Figure 12**, we show that the risk of species' extinctions rises due to global warming, with over 10% of species projected to become endangered at 1.58°C, over 20% at 2.07°C and 50% at 5°C. Most worrying is the projected decline in ocean animal biomass (–5% for every 1°C = –5%–7% fewer fish) as fish provide 17% of humans' average per capita animal protein intake and 60% of global fisheries are at very high risk under 4°C.

Biodiversity can also help mitigate climate change. Nature absorbs more than 50% of anthropogenic CO2 emissions through photosynthesis and consequent carbon storage in biomass and organic material, as well as through CO2 dissolution in ocean water (IPCC). Biodiversity is an essential element in this process as healthy ecosystems perform this natural sequestration. It also contributes to ecosystems providing a more resilient response to adverse physical climate impacts, e.g. through providing storm surge protection.

But climate change inhibits the effectiveness of mitigation: One of the examples that the IPCC identifies as inhibiting the ability of nature to

mitigate climate is shown in **Figure 13**. As the temperature increases above 1.5 degrees (SSP1–1.9), the ability of the land and sea to sequester carbon declines dramatically. As emissions increase and temperatures rise, the emissions stored in the land and the ocean decline exponentially. Therefore, nature's inherent ability to sequester carbon becomes less effective.

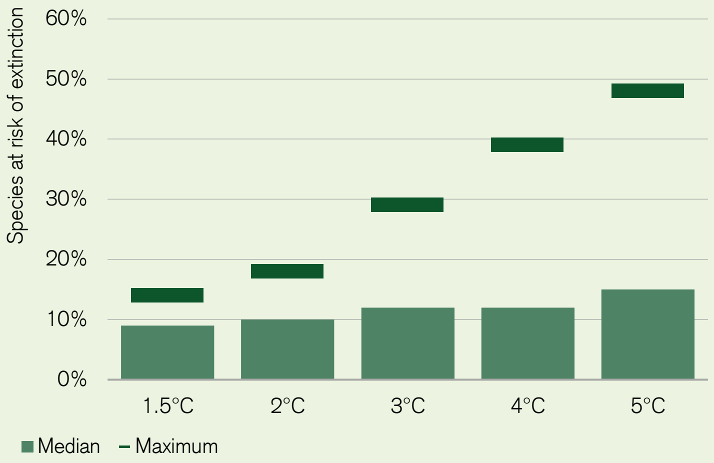
Failing to integrate this into solutions drives adverse outcomes: Ecosystem degradation through land-use changes is a major contributor to both climate change and biodiversity loss. These phenomena exacerbate self-reinforcing feedback, with complex interactions of climate change, land-use change, carbon dioxide fluxes and vegetation changes. When combined with insect outbreaks and other disturbances, this can affect the future carbon balance of the biosphere. Therefore, if biodiversity is not factored into the policy response to climate change, its contribution to attenuating climate change is at risk.

Marine biodiversity

Marine biodiversity is more important to climate mitigation than first understood: the main greenhouse gas (GHG) is water vapor, which accounts for 75% of all GHGs. The second most important is carbon dioxide, followed by methane. As it is not considered possible to directly regulate atmospheric water vapor, climate action has focused mainly on reducing carbon dioxide emissions. Seventy-one percent of the Earth is ocean, which is covered by a surface microlayer of 1–1,000 nanometers composed of lipids and surfactants produced by marine phytoplankton. This microlayer promotes the formation of aerosols and clouds, and slows the transfer of thermal energy to the atmosphere by slowing the escape of water molecules.

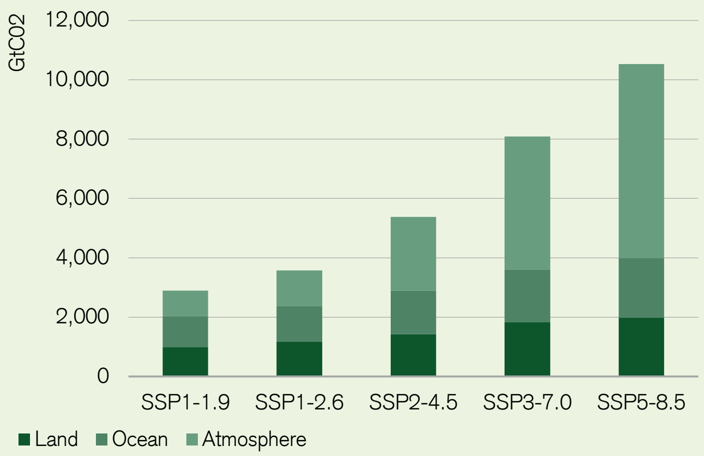
However, chemical pollution has interfered with this mechanism. The surface microlayer attracts "toxic forever" lipophilic chemicals, as well as plastic and black carbon soot from the incomplete combustion of fossil fuels. The consequence is increased evaporation from the ocean's surface into the atmosphere, contributing significantly to global warming. Therefore, in addition to eliminating pollution, we also need to reduce CO2 emissions because they result in an increase in ocean acidification. The resulting dissolution of marine life forms releases locked-up carbon in the deep ocean. The decline in marine phytoplankton will in turn accelerate the process of ocean acidification and cause a regime shift in the aquatic food web that could lead to the loss of all seals, birds, whales, fish and the food supply for three billion people.

Figure 12: Percentage of species at risk of extinction at different levels of warming



Source: IPCC, Credit Suisse

Figure 13: Total cumulative emissions absorbed by natural sinks



Source: IPCC WG1

Photo: Webkatrin001, iStock

Soil: A key biodiversity theme

Often the issues surrounding land use, climate change, the food system and biodiversity are reviewed to some extent in isolation, even though they are all heavily interlinked. Furthermore, in the case of biodiversity, analysis is often focused on animals or above-ground organisms. However, we believe that soil biodiversity is of equal importance and an area that is likely to see an increased level of investor engagement as more data becomes available and the relevance of a healthy soil biodiversity for the wider economy is better understood.

Soil plays a key role in carbon sequestration

Soil organic carbon (SOC) is part of the global carbon cycle and involves the cycling of carbon through the soil, vegetation, oceans and the atmosphere. Carbon sequestration in relation to soil involves three stages: (1) the removal of CO2 from the atmosphere through photosynthesis, (2) the transfer of carbon from CO2 to plant biomass, and (3) the transfer of carbon from plant biomass to the soil where it is stored.

The role that soil-based carbon storage plays in relation to emission reduction is very significant. Various studies have been conducted over the years that have tried to estimate the size of SOC. While the estimates vary, we find that the average amount of SOC is around 1,500 petagrams of carbon (PgC) for the first 100 cm of soil (see **Table 1**). To put this into context, this is more than the amount of carbon that is stored in the atmosphere and terrestrial vegetation combined.

Maintaining, or better yet, increasing levels of soil-based carbon storage not only helps to achieve emission reduction targets and therefore the United Nations' Sustainable Development Goal 13 (Climate Action), but also supports several of the other Sustainable Development Goals (SDGs). It helps to improve soil fertility and productivity, aids water storage and the supply of clean water, and maintains biodiversity in a broad sense. These factors all provide support for SDG 2 (Zero Hunger), SDG 3 (Good Health and Well Being), and SDG 6 (Clean Water and Sanitation),

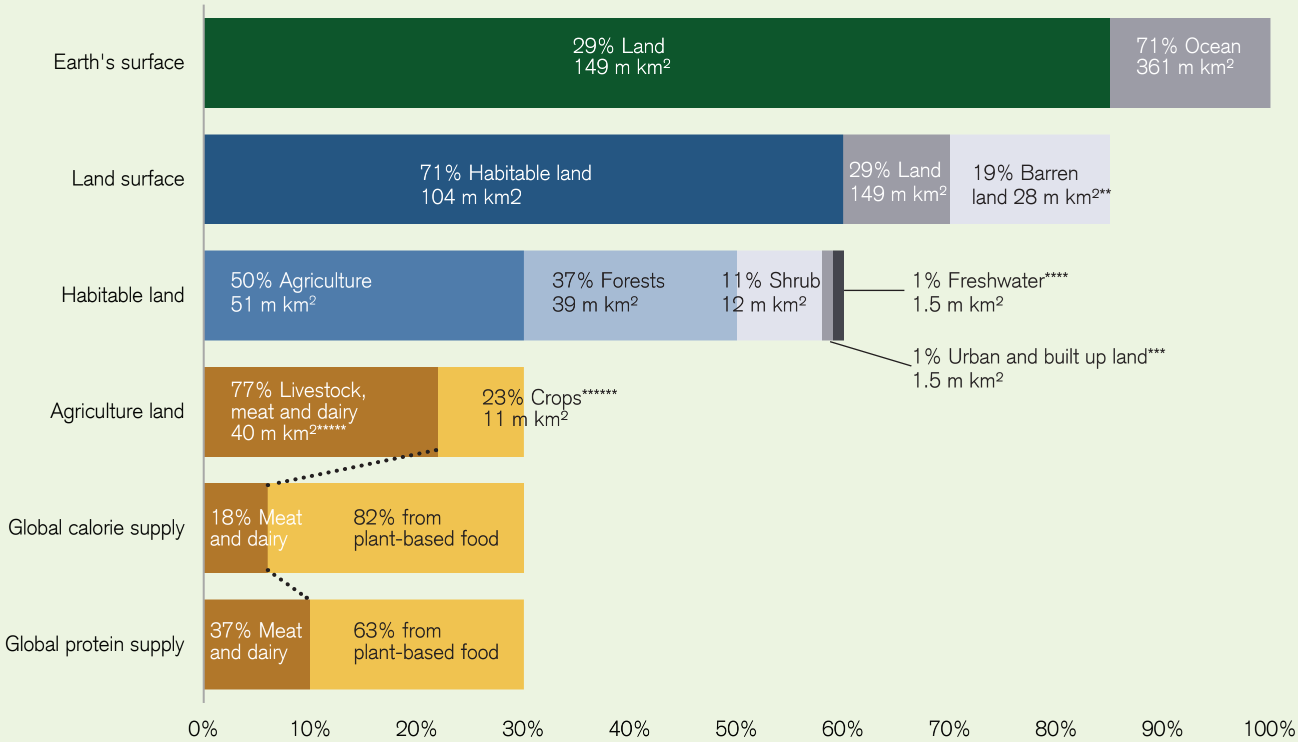
Usage of the Earth's land has changed significantly over the past few hundred years (**Figure 2**). For example, woodlands,

Table 1: Estimates for soil organic carbon storage

	S=C stock (PgC)			
Reference	**0–30 cm**	**0–100 cm**	**0–200 cm**	**0–300 cm**
Batjes (1996)	684–724	1,462–1,548	2,376–2,456	
Jobbagy and Jackson (2000)		1,502	1,993	2,344
Global Soil Data Task Group (2000)		1,550		
Hiederer and Kochy (2011)		1,417		
Scharlemann et al (2014)		1,461		
Shangguan et al (2014)		1,455		1,923
Kochy et al (2015)		1,062–1,325		
Batjes (2016)	755	1,408	2,060	

Source: FAO, Credit Suisse

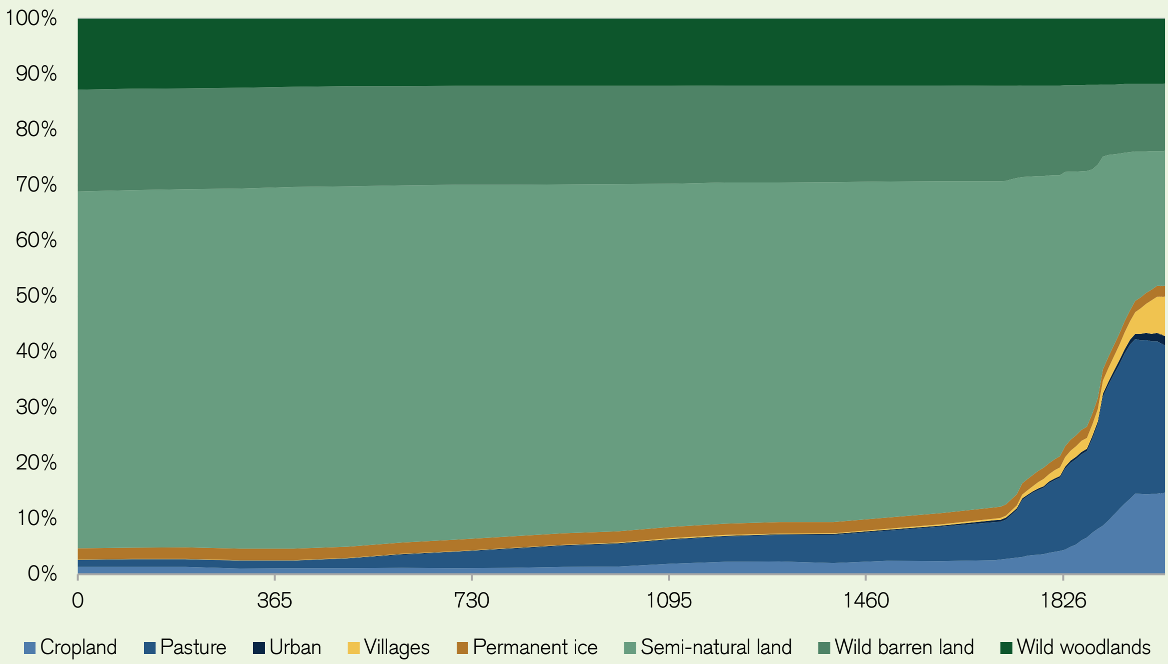
Figure 1: Agriculture makes up 50% of all habitable land



* 14 m km² of which is the land area of Antarctica
** This includes the world's deserts, salt flats, exposed rocks, beaches and dunes
*** This includes settlements and infrastructure
**** Lakes and rivers
***** This includes grazing land for animals and arable land used for animal food production
****** Excluding feed

Source: FAO

Figure 2: The share of forests has declined through time



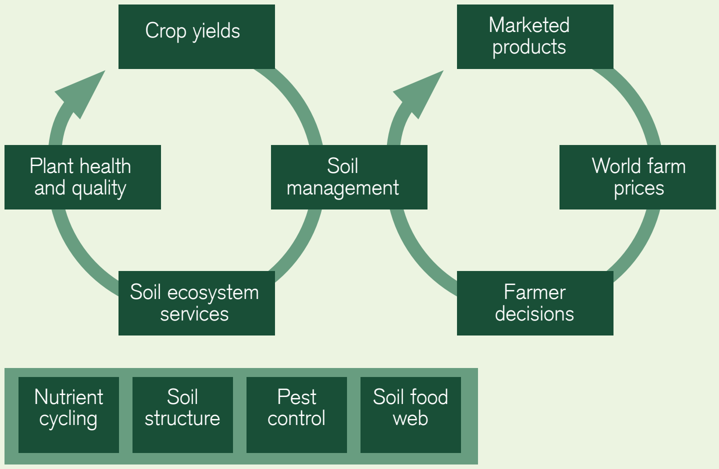
Source: Ellis, Beusen, Godewijk (2020)

semi-natural land and wild barren land made up more than 90% of the world's land surface a thousand years ago. Agriculture comprised no more than a few percent of total land use. Today, however, agricultural land makes up 50% of total habitable land on Earth (**Figure 1**). Improving soil quality or soil biodiversity has thus become a question of establishing sustainable agriculture-related land-management practices.

Current land-use practices are unsustainable

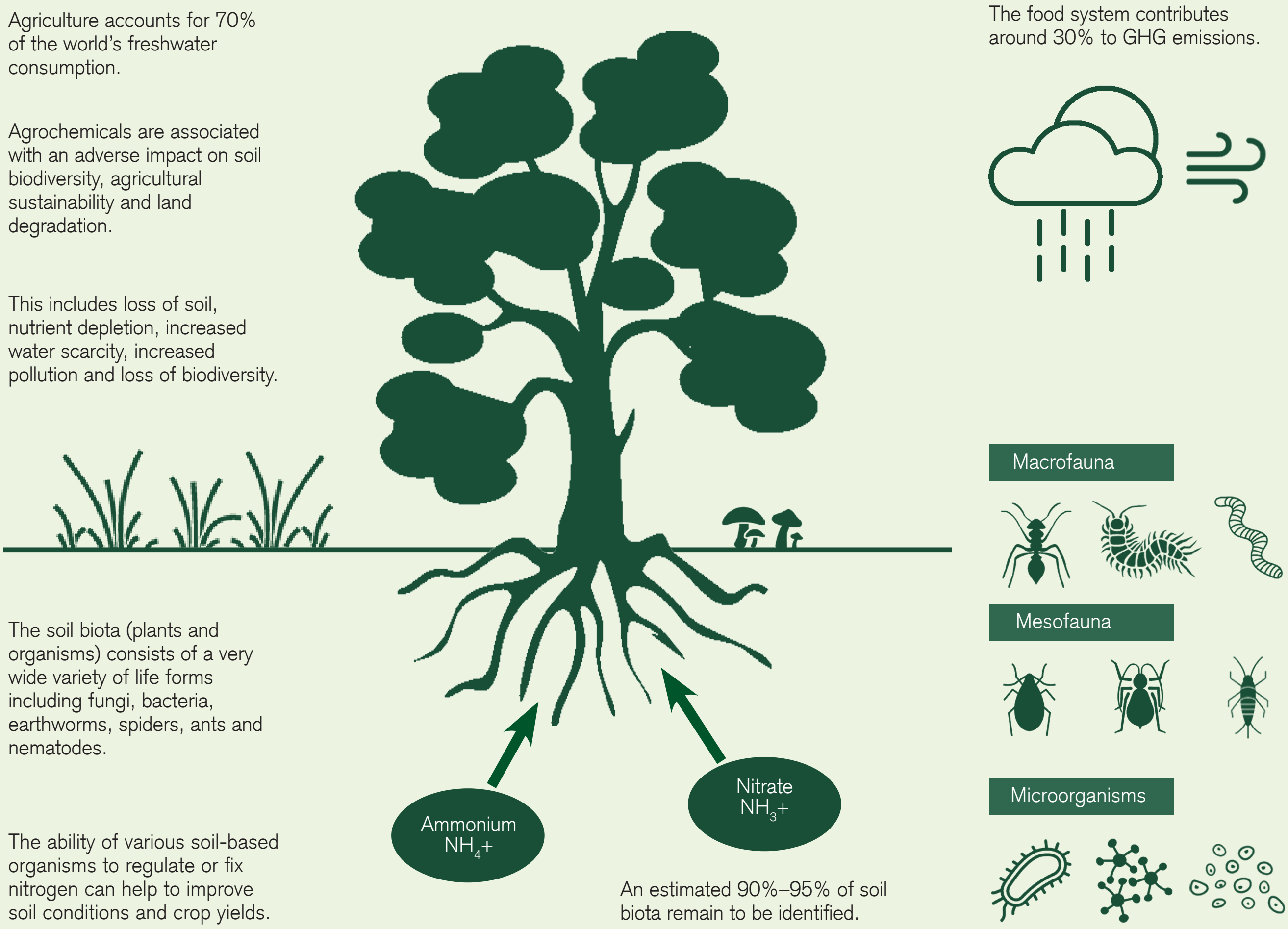
Land is one of the most essential natural resources and land use plays a key role in relation to most of the SDGs in our view. However, agriculture, or in a broader sense the food system, is one of the key threats to our world's boundary conditions. For example, the food system contributes around 30% to GHG emissions and is the main driver of nitrogen and methane emissions (FAO). Increased demand for food

Figure 3: A conceptual model for understanding the impact of soil ecology, biodiversity and the broader economy



Source: Plaas et al (2018), Credit Suisse

Figure 4: Soil biodiversity determines agricultural performance



Source: Credit Suisse

production also contributes to deforestation, while agriculture also accounts for 70% of the world's freshwater consumption. With the global population set to grow to around ten billion people by 2050, according to the United Nations, and with the expected further increase in average consumer spending power across developing countries, we expect these threats to increase unless action is taken.

While total land used for agricultural purposes has grown substantially over the past few hundred years, this has not been sufficient to meet the incremental demand for food from a growing and wealthier global population. As a result, crop yields have needed to rise as well in order to improve average food production per hectare. To achieve this, the use of agrochemicals such as fertilizers, pesticides and herbicides has grown rapidly. Some studies have found that the need for agrochemicals is likely to continue growing given that the expansion of agricultural land is likely to slow down. Ramankutty et al (2018) suggested that 80% of future production growth is likely to come through increased production yields.

One of the problems with the increased intensive usage of agrochemicals is that they are associated with an adverse impact on soil biodiversity, agricultural sustainability and land degradation (Meena et al, 2020). The latter includes loss of soil, nutrient depletion, increased water scarcity, increased pollution and loss of biodiversity (Bai et al, 2008). This clearly puts a range of sustainable targets at risk, especially knowing that, in North Africa and the Near East, up to 66% of the current population live in degraded areas. Land degradation today affects 29% of the global land area and 28% of the global population (Le et al, 2014).

Agricultural intensification has contributed to a loss of landscape heterogeneity and biodiversity. A more homogenous farming system reduces the number of natural predators, which in turn is likely to increase crop-pest infestations and lead to a higher reliance on pesticides. To underline the intensification of agriculture, we note that, according to the United Nations Food and Agriculture Organization (FAO), only nine of the more than 6,000 plant species that have been cultivated for food accounted for 66% of total global crop production in 2014.

Based on the above, it appears that agricultural practices need to change in order to reduce the environmental risks associated with the current trajectory. The move to a more sustainable agricultural system needs to be achieved without putting more strain on food production levels, especially in food-insecure regions. A healthy soil biodiversity appears to be key, in our view, when trying to improve the sustainability of the world's agricultural ecosystem.

Agriculture, soil and biodiversity

In 1992, the United Nations defined biodiversity as the variability of living organisms and the ecological complexes that they are part of. As part of the debate around biodiversity, we believe that agricultural biodiversity should receive high priority given its relevance to the world's ecosystems and a wide range of sustainability targets. For example, the need to protect the biodiversity of pollinators appears obvious when realizing that 78 of humanity's major food crops accounting for around 35% of global food production depend on animal pollination (study from Klein et al, 2007). Analysis from the IPBES in 2018 indicated that between USD 235 billion and USD 577 billion of annual global food production relies on pollination.

"

Agricultural intensification has contributed to a loss of landscape heterogeneity and biodiversity

In our experience, biodiversity-related discussions tend to focus mostly on above-ground living species (domesticated and wild) and ecosystems. We believe that such a focus misses or underestimates the relevance of soil-based biodiversity.

The soil biota (plants and organisms) consists of a very wide variety of life forms including fungi, bacteria, earthworms, spiders, ants and nematodes. These organisms are typically classified into three major groups based on their size. Macrofauna consist of organisms with a size of 2–20 mm, mesofauna have a size of 0.1–2 mm and microorganisms have a size of less than 0.1 mm. One reason why soil-based biodiversity tends to receive less focus might be the fact that much remains unknown about the soil biota. For example, some studies suggest that an estimated 90%–95% of soil biota remain to be identified. **Table 2**, for example, shows that the share of microorganisms that have been described is very low.

The relevance of a healthy soil biodiversity becomes clear when understanding the function that the various groups fulfil:

- Macrofauna: These species help to maintain a good soil structure by ingesting soil organic matter and mineral particles, mixing and aggregating soil and burrowing and releasing nutrients to plants.
- Mesofauna: These species break down organic matter and deposit feces, which helps to improve soil fertility.
- Microfauna: These species consist of an extremely broad group of organisms, although only a fraction are known globally. Microfauna such as nematodes play a key role in regulating and releasing nutrients such as nitrogen and phosphorus, which in turn help to stimulate root growth. The existence of nematodes is therefore a good indicator of biological activity in the soil. Fungi are the primary actors of plant litter decomposition and their hyphal networks enable the distribution of nutrients that plants benefit from. For investors seeking a deepdive into the role of fungi we refer to "Entangled life" by Merlin Sheldrake.

Table 2: Global diversity of soil organisms

Nutria	Sub-groups	Species described	Estimated no. of species existing	Percentage described
Vascular plants		350,700	400,000	88
Macrofauna	Earthworms	7,000	30,000	23
	Ants	14,000	25,000–30,000	50-60
	Termites	2,700	3,100	87
Mesofauna	Mites	40,000	100,000	40
	Springtails	8,500	50,000	17
Microfauna and microorganisms	Nematodes	20,000-25,000	1-10 million	<2.5
	Protists	21,000	7–70 million	<0.03
	Fungi	97,000	1.5–5.1 million	<0.02
	Bacteria	15,000	> 100,000	<1.5

Source: IUCN, De Deyn & van der Putten (2005), Diana Wall et all (2011)

Why healthy soil matters

There are several functions that the soil biota fulfil that are key in ensuring that the world's natural capital, agricultural and food systems are sustainable. Nutrient cycling is one of these. The ability of various soil-based organisms to regulate or fix nitrogen can help to improve soil conditions and, importantly, crop yields. For example, work from Souza et al ("Use of nitrogen-fixing bacteria to improve agricultural productivity," 2014) showed that yield increases of 5%–30% could be achieved. This in turn reduces the need for (non-organic) fertilizer use.

The fact that soil organisms decompose organic matter into nitrogen, phosphorus, sulphur and carbon is highly relevant. Although microorganisms account for around 90% of decomposition activity, work from Lavelle et al (1997) suggests that other soil organisms play a facilitating role in this process. Improving the soil biodiversity by increasing the presence of various organisms can have a very meaningful impact on crop productivity. For example, agroecosystems with a low nitrogen content, but average earthworm presence, tend to have 25% higher crop yields and 23% higher above-ground biomass compared to systems that do not have earthworm presence. This is related to the release of nitrogen and therefore provides an alternative to the use of fertilizers. Work from Van Groeningen et al ("Earthworms increase plant production," 2014) also suggests that crop yields for wheat, rice, barley and grain tend to be more than 30% higher on average in areas with earthworms compared to those without. Pest and disease control is often carried out using

Table 3: Impact of activities on soil biota

Agricultural action	Primary production system	Effect on soil biota
Chemically treated soils	Application of pesticides and fertilizers	Strong impact on soil biodiversity, alters bacterial and fungal communities, may inhibit certain fungi, can affect growth and survival of amphibians and affect nematode community compostions with an impact on nutrient and cycling processes.
Tilled soils	Organic farming, conservation farming, conventional farming, biological pest control, manure/compost applications	Tillage can have positive as well as negative effects on the biomass of soil organisms, especially earthworms, nematodes and fungi. If the nematodes and earthworm biomass decreases, a decline in soil structure and stability is likely with reduced nutrient uptake and weaker biological control of pathogens.
No-tilled/reduce tilled soils	Organic farming, conservation farming, conventional farming, biological pest control, manure/compost applications	Likely to result in increased soil microbial biomass (fungi and bacteria) as well as earthworms. This in turn increases soil structure and stability, nutrient uptake, SOM and biological control of pathogens.

Source: IUCN

chemicals or non-organic materials. However, studies show that a healthy soil biota enhances fertility and plant health, which in turn reduces the risk of susceptibility to pest and disease attacks and therefore the need for pesticides.

Various agricultural practices can have a negative impact on soil biodiversity and ecosystems (**Table 3**). For example, the use of nitrogen fertilizer changes the ratio of carbon to nitrogen in the soil, which negatively impacts bacterial and fungal communities and therefore nutrient cycles. Pesticides can result in lower nitrogen fixing and plant yield, and a decline in the structure or health of microbiota. Farming practices such as tillage also affects soil biota, which can (among other factors) result in declining soil species diversity which in turn is likely to depress crop yields and result in increased usage of chemicals such as nitrogen fertilizers. We refer here also to interesting work from Plaas et al ("Towards valuation of biodiversity in agricultural soils"), which shows that a move to conservation tillage increased the gross margin for winter wheat in Lower Saxony (Germany) by 23% to EUR 699 per hectare, suggesting that changing farming practices may also have immediate positive financial implications.

> "
> # Studies show that a healthy soil biota enhances fertility and plant health

Sustainable farming solutions

Improving or maintaining soil health requires the adoption of sustainable agricultural policies and procedures. Several different sustainable farming approaches are in use today. While a uniform definition of these does not exist and overlap does occur, we highlight some of the key sustainable approaches below.

- Agroecology is one of the oldest sustainable agricultural approaches. The focus is to optimize and stabilize production yields. Agroecology aims to increase the quantity and quality of food production, manage pest populations more efficiently and effectively and reduce the reliance on input factors.
- Organic farming aims to avoid the use of synthetic fertilizer and pesticides. To achieve this it relies on ecological processes, biodiversity and production cycles that are adapted to local conditions.
- Regenerative agriculture seeks to enhance and sustain the health of its soil by restoring its organic matter. Furthermore the goal is to boost productivity and fertility. While the focus is on enhancing the health of the soil, we note that regenerative farming does not necessarily ban the use of synthetic pesticides and fertilizers. Activities typically associated with regenerative farming include the abandoning of tillage, the elimination of bare soil, fostering plant diversity, encouraging water percolation into the soil and the integration of cropping with livestock operations.
- Mixed farming remains one of the most common farming systems across the developing world. Producing livestock and crops on the same farm is gaining popularity as it is seen as helping to improve the nutrient cycles through the use of circular economy thinking, among other things, i.e. using crops and grasslands to feed animals and in return organic manure for fertilization or biogas.
- Conservation agriculture is mainly focused on minimum mechanical soil disturbance with permanent organic soil cover (of at least 30%) using crop residues or cover crops. This enables the diversification of species by using at least three different crops as part of a varied crop sequencing approach. The European Conservation Agriculture Federation (ECAF) highlights that conservation agriculture yields a range of environmental benefits, including an improvement in soil biodiversity as well as financial gains.
- Agroforestry is where the use of trees is part of the overall farming approach. Integrating tree planting into farming operations has various benefits, including increased income, improved food security, and greater conservation of biodiversity and the ecosystem. Agroforestry not only improves soil quality, but, importantly, also reduces soil erosion. Water runoff is less of an issue as well, which suggests that more water is available for plant production and infiltration. Farmers who expand tree-planting activities may also be in a position to enter into carbon storage agreements that yield carbon credits, which could potentially increase farming revenues further.

Dainese et al also highlight the relevance of more diverse farming activities (A global synthesis reveals biodiversity-mediated benefits for crop production, 2019) in a study showing that greater landscape simplification, greater species richness and improved pollination are needed to improve crop or food production levels (see **Figure 5**).

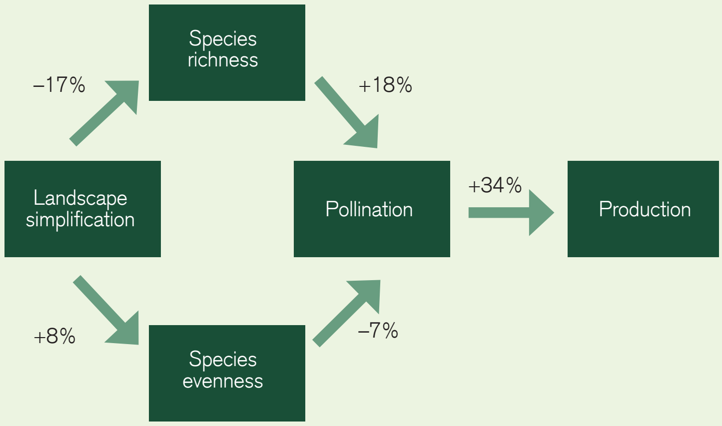
The "4 per 1000" initiative

The International "4 per 1000" initiative launched by the French government in December 2015 at the COP 21 Paris Climate Conference is another way of illustrating the potential of greater soil biodiversity. It aims to increase carbon storage in the top 30 to 40 centimeters of soil by 0.4% per year. Analysis performed for the IUCN shows that a successful implementation of the "4per1000" initiative could:

- Capture one gigaton (Gt) of carbon per year over the next 30 years.
- Avoid social costs of around USD 600 billion per year through climate change mitigation over the 2020–50 period.
- Boost the production of maize, wheat and rice between 2020 and 2050 by 23% to 42%, representing an annual incremental value of at least USD 135 billion.
- Store an additional 37 billion cubic meters of water in soils, which reduces global irrigation demand by 4% and saves over USD 40 billion per year in costs.
- Increase the resilience of farming communities in the face of climate change, reducing reliance on chemical fertilizers and offsetting the demand for further land conversion.

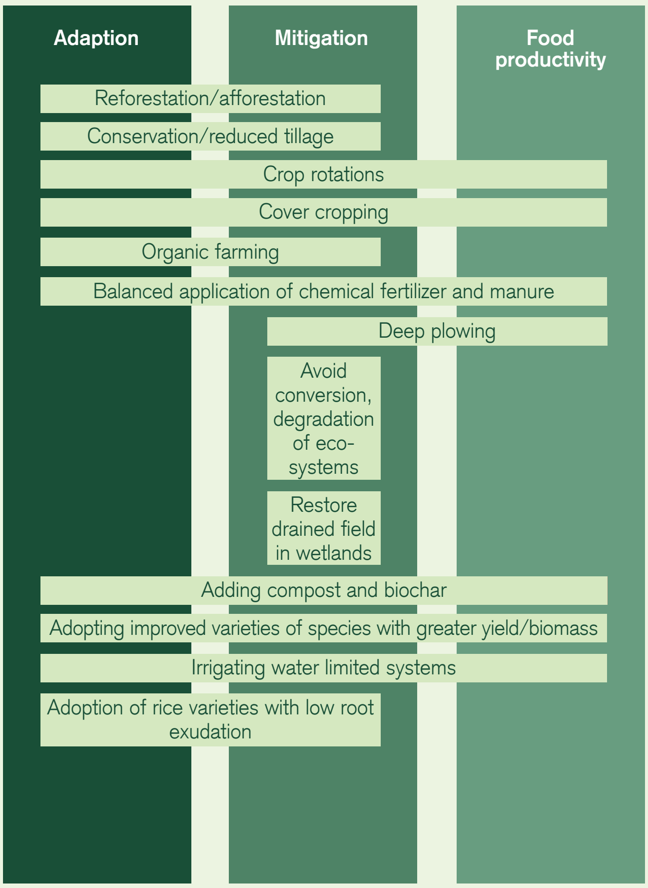
Based on the solutions highlighted above, we use data from the FAO in its analysis from 2017 (Soil Organic Carbon: The Hidden Potential), which showed how various solutions impact climate change mitigation or adaptation, and whether they also positively affect the sustainability of food production (**Figure 6**).

Figure 5: Regression coefficients between landscape, species, pollination and production in ecosystems



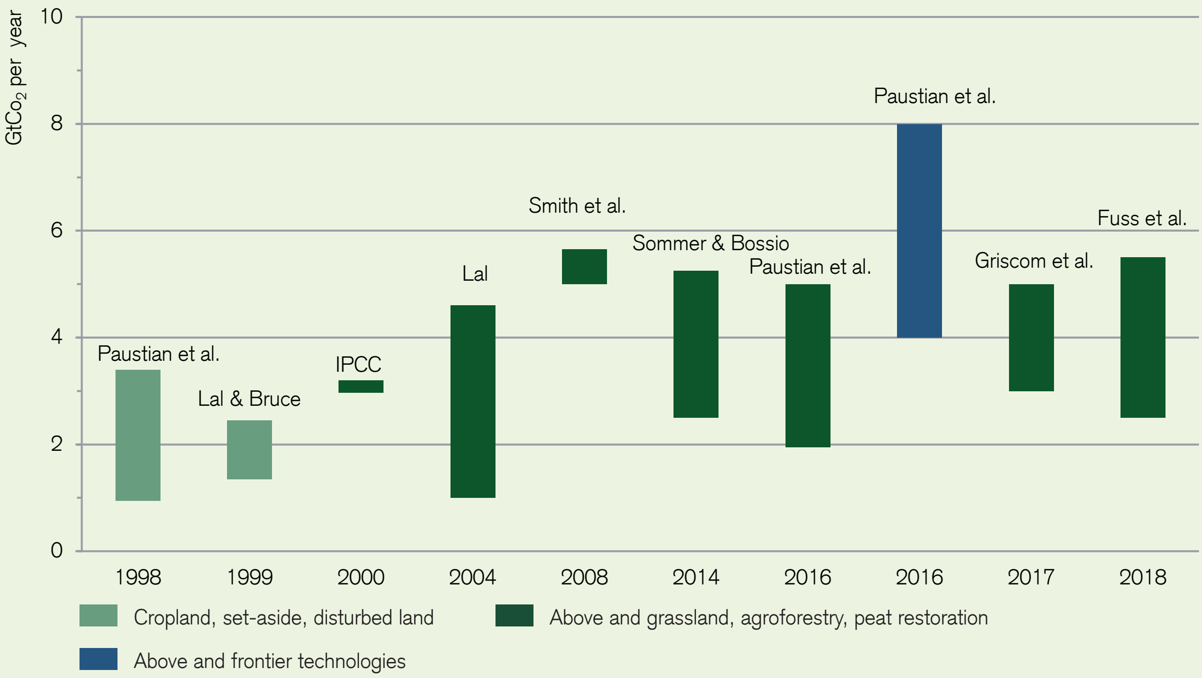
Source: M. Dainese et al, 2019, Credit Suisse

Figure 6: Suggested soil management strategies and their impact on food productivity and climate change adaption and mitigation



Source: FAO "Soil Organic Carbon the Hidden Potential," 2017

Figure 7: Global biophysical soil carbon sequestration potential assuming (near) full adoption of carbon sequestration practices



Source: Paustian et al (2016)

While these practices help to improve biodiversity, they also help to increase carbon storage. In 2019, Paustian et al provided insight into what the impact on carbon storage could be if these practices were widely adopted in their study "Soil C Sequestration as a Biological Negative Emission Strategy." Their analysis suggests that 4–5 gigatons of CO2 per year could be sequestered. Including what they define as "frontier technologies," this annual estimate could be as high as eight gigatons of CO2 per year, which alone would represent around 20% of current annual GHG emissions (**Figure 7**).

This chapter outlined the relevance of healthy soil for the functioning of broader ecosystems, carbon sequestration and therefore ultimately climate change. Furthermore, we highlighted a number of land use and agricultural strategies that can help improve soil biodiversity.

Having identified the state of biodiversity during the first few chapters of this report, we will, in the remainder, outline how biodiversity-related regulation is likely to evolve in our view. Furthermore, we will review the performance of key countries in terms of biodiversity as well as the investment requirements associated with nature-based solutions.

Photo: Sandralise, iStock

Biodiversity and the institutional response

The institutional response to biodiversity is gaining traction, helped by the Convention on Biological Diversity and supported by the IPBES. However, implementation at a national level is insufficient in our view. While most countries have legislation focused on environmental protection, using the Yale Environmental Performance Index we find that the degree to which biodiversity is considered and captured in protected areas remains a question mark.

A path through the biome – mapping the institutional framework

The United Nations Environment Programme (UNEP) is the global authority that sets the environmental agenda. Since its inception in 1972, UNEP has been promoting the implementation of the environmental dimension of sustainable development within the United Nations system. In 1992, the United Nations Conference on Environment and Development, also known as the "Earth Summit," was the catalyst that formed the foundations of the global agenda on nature and climate change. At the summit, both the Convention on Biological Diversity (CBD) and the Framework Convention on Climate Change (UNFCCC) were created.

The CBD is the legal instrument for conserving biodiversity. The CBD is a multilateral treaty with three main goals: (1) the conservation of biological diversity, (2) the sustainable use of its components, and (3) the fair and equitable sharing of benefits arising from genetic resources. The convention has 196 parties, including 195 states and the European Union. The CBD was also instrumental in creating a universal definition of biodiversity, which is now used throughout the institutional framework. All United Nations member states — with the exception of the USA — have ratified the treaty, which means all signatories are bound by the international act.

National Biodiversity Strategies and Action Plans (NBSAP) are used by member states as the principal instruments for implementing the CBD at the national level. The convention requires that countries prepare a national biodiversity strategy and ensure that this strategy is included in planning for activities in all sectors where diversity may be impacted. In accordance with Article 26 of the convention, parties must prepare national reports on the status of the implementation of the convention.

The IPBES is to the CBD what the IPCC is to the UNFCCC. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is the intergovernmental body that provides policymakers with objective scientific assessments of the planet's biodiversity and ecosystems. The IPBES also plays a critical role in developing the tools and methods to protect and sustainably use natural assets. It works in a similar way to the IPCC, the United Nations body for assessing the science related to climate change. Its 2030 work program includes: (1) understanding the importance of biodiversity in achieving the 2030 Agenda for Sustainable Development (2) understanding the underlying causes of biodiversity loss and determinants of transformative change and options for achieving the 2050 Vision for Biodiversity, and (3) measuring business impact and dependence on biodiversity.

The United Nations considers biodiversity integral to the SDGs. The United Nations' 17 Sustainable Development Goals (SDGs) were developed to be consistent with existing international agreements and commitments, including the Aichi Targets set by CBD under the Strategic Plan for Biodiversity 2011–20. The plans are mutually reinforcing, so that the implementation of one contributes to the achievement of the other. Upon the launch of the SDGs, the CBD released a technical note identifying synergies between the two strategies. Two of the SDGs that directly relate to biodiversity conservation are:

- SDG 14 – Life below water: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
- SDG 15 – Life on land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss.

However, the Aichi Targets also indirectly relate to all the SDGs due to the intrinsically linked notions of sustainable development and sustainable use of and interaction with nature. For example, it is a key factor for the achievement of food security and improved nutrition (SDG 2) and the provision of clean water (SDG 6). All food systems depend on biodiversity and the range of ecosystem services that support agricultural productivity, e.g. pollination, pest control and soil fertility.

The IUCN and the Red List have been instrumental to biodiversity policy. The International Union for Conservation of Nature (IUCN) created the Red List of Threatened Species in 1964. It has since evolved into the world's most comprehensive data source on the global extinction risk of species. The IUCN also played an important role in the creation of the key United Nations international conventions that we highlight in this report.

In March 2021, the United Nations statistical commission adopted a new framework for environmental accounting, i.e. the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA). This marked a major step forward, going beyond the commonly used GDP statistics that have dominated economic reporting since the end of World War II to develop a new system of measuring economic prosperity and human well-being that includes the contributions of nature. The SEEA EA ensures that natural capital – such as forests, wetlands and other ecosystems – are recognized in economic reporting. A benefit of this has been that aspects of biodiversity have been incorporated into economic planning and policy decision-making, which could have a significant impact on efforts to address critical environmental emergencies. The SEEA EA is built on five core accounts that are compiled using spatially explicit data and information about the functions of ecosystem assets and the ecosystem services they produce.

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A benefit of this has been that aspects of biodiversity have been incorporated into economic planning and policy decision-making

Within the broader United Nations international framework, we have identified six other conventions that directly relate to achieving biodiversity outcomes. We provide a brief summary of each of these in **Table 1**. Overall, the United Nations provides a comprehensive institutional framework that governs the international response to biodiversity. In **Figure 1**, we summarize the chronological developments.

How does this translate into laws and regulations?

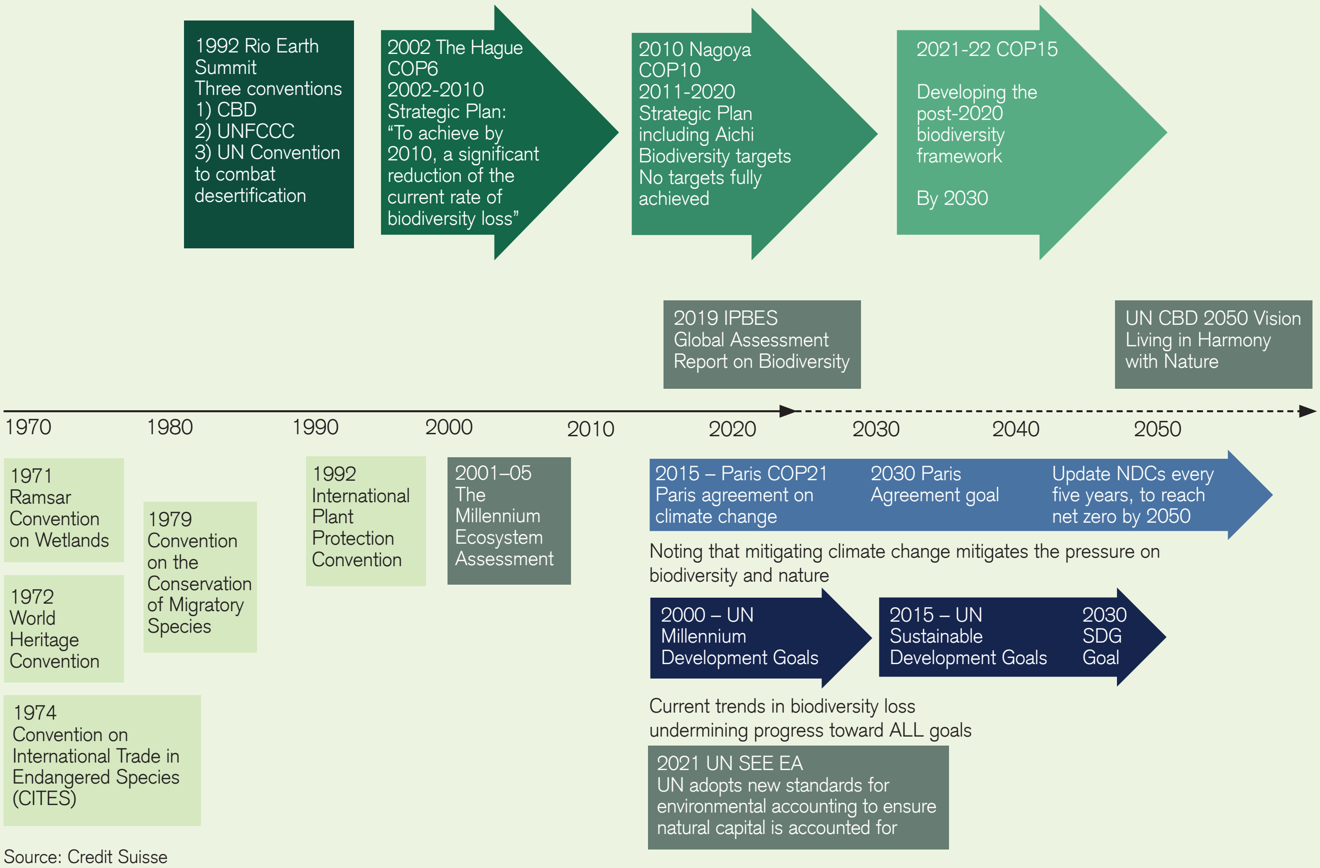
In addition to the international institutional frameworks that govern biodiversity, it is important to understand how biodiversity conservation is implemented at a national level and its effectiveness in delivering positive outcomes. In this section, we provide an overview of the legal and regulatory settings in order to indicate the strength of regulation and the relative risks that are emerging for corporates and investors.

Table 1: Other UN conventions that relate to biodiversity

Convention title	Description
International Whaling Commission (1946)	The IWC manages whaling and conservation of whales. An integral part of the convention is its legally binding "Schedule." The Schedule sets out specific measures that the IWC has collectively decided are necessary in order to regulate whaling and conserve whale stocks. These measures include catch limits (which may be zero as is the case for commercial whaling) by species and area, designating specified areas as whale sanctuaries, protection of calves and females accompanied by calves, and restrictions on hunting methods.
Ramsar Convention on Wetlands (1971),	The purpose of Ramsar is to conserve all wetlands through all levels of government to achieve global sustainable development. It uses a broad definition of wetlands including all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans. Contracting parties commit to protecting wetlands.
World Heritage Convention (1972)	The WHC is governed by UNESCO and parties pledge to conserve World Heritage sites. To be included on the List, sites must be of outstanding universal value and meet at least one out of ten selection criteria. Four of the criteria relate to outstanding natural universal value including significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1974)	CITES is an international agreement between governments to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species. It assigns varying protection to over 36,000 species. Parties must not trade in listed species and must prohibit and penalize trade in violation of the convention. Annually, over one million CITES permits and certificates are issued estimated to be worth billions of dollars and ranging from live animals to food products and wood instruments.
Convention on the Conservation of Migratory Species of Wild Animals (1979)	CMS provides a global platform for the conservation and sustainable use of migratory animals and their habitats. Migratory species threatened with extinction are listed in Appendix I of the convention. CMS parties aim to strictly protect these animals, conserving or restoring the places where they live and mitigating issues causing endangerment.
International Plant Protection Convention (1992)	The IPPC is governed by the FAO and protects cultivated and wild plants by preventing the introduction and spread of pests. The Convention introduced the International Standards for Phytosanitary Measures (ISPMs) as its main tool to achieve its goals, making it the sole organization setting global standards for plant health.

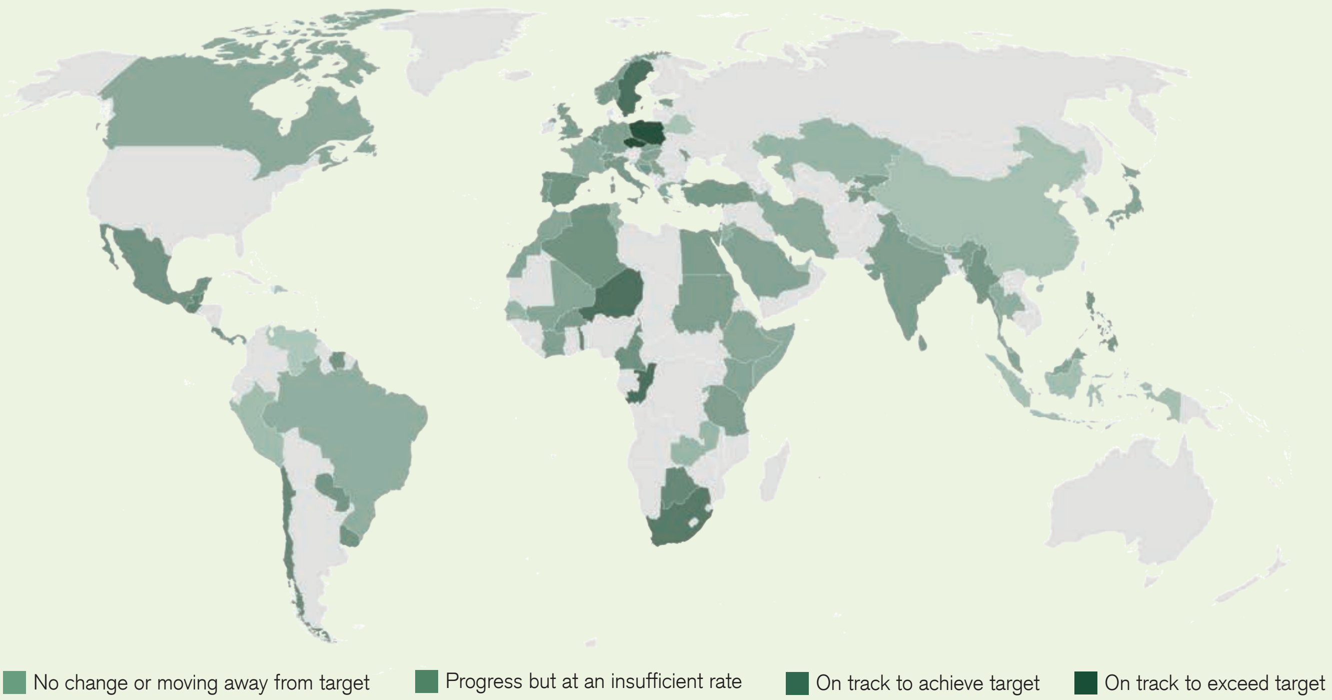
Source: Credit Suisse

Figure 1: Timeline of key developments that relate to biodiversity



Source: Credit Suisse

Figure 2: Aichi progress assessment – overall most countries have made progress, but at an insufficient rate



Source: United Nations CBD, Credit Suisse

The Aichi progress review provides the most authoritative indication of the impact of regulation. Most parties to the convention submit national reports on their progress in achieving the goals through the Clearing-House Mechanism (CHM) of the CBD. Under the current Aichi Targets, this resource provides a centralized database of countries' progress toward each of the 20 goals and the CBD provides an assessment as to whether the reported progress is on track to meeting each goal. The assessment considers a range of indicators from the Biodiversity Indicators Partnership (BIP) in addition to the nationally prepared reports. This assessment is the best indication of the effectiveness of biodiversity legislation and regulation from a macro-ecological perspective.

The review shows that most countries have made insufficient progress. Of the 93 countries that reported under the CHM, the majority have made at least some progress, but still not enough to achieve the Aichi Targets. From a regulation perspective, this indicates that the current regimes in those countries are insufficient to incentivize, enforce and deliver on biodiversity outcomes. The countries mostly on track to meet the targets were Venezuela, Belarus, the Dominican Republic and China, whereas the countries that have made the least progress are Niger, Congo, Sweden and Poland. We show the outputs of this assessment in **Figure 2**. Countries that do not have data did not submit their national reports to be assessed under this publicly available mechanism. The USA is an exception as it has failed to ratify the CBD until now.

Most countries have a cornerstone environmental protection legislation that sets the powers and responsibilities of government regulators and provides details on the scope of protection and level of enforcement. Across countries, however, there is seldom homogeneity in the structure and scope of the laws. In **Table 2** we outline the primary environmental legislation for a sample of countries and trading blocs, providing an outline of the scope of the laws alongside the average Aichi score, where applicable.

In reality, environmental and biodiversity outcomes are shaped by a range of policy settings. In the previous chapter, we described how biodiversity is impacted by five key drivers, i.e. land and sea-use change, resource use, climate change, pollution and invasive alien species. Typically, governments have legislated across all of these areas, creating a patchwork of regulations addressing biodiversity. However, these contiguous laws seldom consider the biodiversity impacts from a systemic perspective and, in the extreme, could drive adverse outcomes. The UK is a good example of the complexity and the sheer number of acts that can impact biodiversity.

Table 2: Summary of primary environmental legislation for key countries and trading blocs

	Law/Regulation	Description	Average Aichi score
Australia	Environment Protection and Biodiversity Conservation Act 1999	The act established processes to help protect and promote the recovery of threatened species and ecological communities. It grants extra protection to Matters of National Environmental Significance (MNES) including World Heritage properties, National heritage places, Ramsar Wetlands, nationally threatened species and ecological communities, migratory species, commonwealth marine areas, the Great Barrier Reef Marine Park, nuclear and coal seam gas (CSG) water and mining. The act works by examining whether proposed action is likely to have a significant impact on any of the MNES, and may require Commonwealth approval before the action can begin. However, the current government has started the process of reforming the act and we expect any changes to lead to a tightening or strengthening of the legislation.	n.a.
China	The 14th Five -Year Plan	The Plan sets targets for protected natural land, forest and grassland coverage, with references to ecosystem repair and protection. In particular, it sets goals to increase forest cover to 24% (currently 23.2%), prevent soil erosion, increase the wetland protection rate to 55% and maintain of at least 25% of natural shoreline. It also places emphasis on "harmony" between nature and human activities and uses previously missing language like "sustainable fishing."	1.98
	Biodiversity conservation whitepaper	China is determined to use an overarching framework for biodiversity conservation, which is now elevated to national strategy. As part of this, China has proposed implementing a national parks system and set ecological conservation red lines (ECRLs). Since 2015, China has piloted its national parks and protected areas, with ten parks covering an area of 2.3%. Trials have been successful, with 90% of terrestrial ecosystem types and 71% of projected fauna species under effective protection as their habitats and populations are growing. For example, wild giant pandas have increased from 1,114 to 1,864. The ECRLs draw a red line around essential and most ecologically fragile regions and apply stringent conservation measures to them.	
European Union	Nature Restoration Law	The European Commission's proposal for a Nature Restoration Law is the first continent-wide, comprehensive law of its kind. It is a key element of the EU Biodiversity Strategy. These measures should cover at least 20% of the EU's land and sea areas by 2030, reverse the decline of pollinator populations by 2030, and achieve an iincrease in pollinator populations. EU countries are expected to submit National Plans to the Commission within two years of the regulation coming into force.	3.1
	Birds and Habitats Directives	The Birds Directive was the first EU biodiversity policy providing protection to the 500 wild bird species. The Habitats Directive establishes the EU wide Natura 2000 ecological network of protected areas to safeguard against potentially damaging developments. It covers 1,000 animal and plant species, and 200 habitats. The EU also has other regulations on invasive alien species and the trading of wildlife.	
India	Environment (Protection) Act 1986	The purpose of the act is to protect and improve the human environment and the prevention of hazards to human beings, other living creatures, plants and property. The Act is an "umbrella" legislation that has provided a framework for the environmental regulation regime, which covers all major industrial and infrastructure activities and prohibits and regulates specific activities in coastal and eco-sensitive areas.	2.83
United Kingdom	Environment Act 2021	The act represents a step up in the level of biodiversity protection, including stricter biodiversity duties and legally binding targets, as well as mandating that new developments must deliver at least a 10% net gain in biodiversity, and prohibiting larger UK businesses from using commodities associated with wide-scale deforestation, requiring them to establish a system of due diligence for each regulated commodity used in their supply chains. The act also introduces a new enforcement system.	2.83
United States	Endangered Species Act 1973	The act obligates federal and state governments to protect all species threatened with extinction in the USA. It requires protection for critical habitat areas and the development and implementation of recovery plans for listed species. Originally very strong, the act was watered down by the Trump administration by removing the automatic protections for "threatened" species and introducing a case-by-case basis for newly listed species. Today it allows federal agencies to consider economic impacts when deciding if a species should be protected. Previously, they had to rely exclusively on scientific evidence and were prohibited from considering economic impacts. Finally, the changes enable federal agencies to ignore climate change when formulating protections for specific species. Climate change used to fall under the scope of threats that may affect a species in the "foreseeable future." However, the Biden Administration is in the process of reviewing and rescinding these amendments.	n.a.
Brazil	National Environmental Policy Act. 1981	The act sets the environmental principles, strategies and standards for environmental impact assessment and polluting permits, and provides enforcement powers. It aims to preserve, improve and recover the environmental quality conducive of a healthy life, with a view to ensuring socioeconomic development, the interests of national security and the protection of human life.	2.49
	National System of Protected Areas Management (SNUC)	The SNUC establishes the categories and regulation of habitats and biodiversity, awarding different degrees of protection and creating a specific governance regime for each category, with restrictions and requirements tailored to human activities. For the categories subject to stricter protection, only scientific research and some limited tourism are allowed.	

Source: Credit Suisse

Table 3: UK nature-related policies by biodiversity impact driver

Land/water/sea change or use	Resource use change	Climate change	Pollution	Invasive species
The Water Act 2003: Governs the management and conservation of water resources. Aims at the sustainable use of water resources, protection of consumer interest, created the Water Regulator, provides provisions for land drainage, flood defense, pollution of controlled waters.	**Sea Fish (Conservation) Act 1967:** Includes restrictions on the commercial use of under-sized fish, measures to increase or improve marine resources, penalties for and offenses and enforcement orders.	**Climate Change Act 2008:** Sets the emissions targets, annual reporting and a system of carbon budgeting. Establish a Committee on Climate Change; to confer powers to establish trading schemes for the purpose of limiting greenhouse gas emissions or encouraging activities that reduce such emissions or remove greenhouse gas from the atmosphere; to make provision about adaptation to climate change.	**Large Combustion Plants Directive (2001/80/EC):** National Emissions Reduction Plan - trading of dust, NOx and SO2 emissions large combustion plants trade emissions allowances. The Environment Agency must verify the annual report of each operator of a participating plant in England and Wales relating to the actual annual mass emission.	**Invasive Alien Species Order 2019**: This Order implements the Regulation (EU) No 1143/2014 of the European Parliament on the prevention and management of the introduction and spread of invasive alien species, places control on the importation and exportation of invasive alien species as listed by the EU Commission in accordance with the Regulation. It provides for civil sanctions, the issue of permits and enforcement.
Marine and Coastal Access 2009: Introduced a new system of marine management, including provisions for licences for activities in the marine and freshwater environment, migratory and freshwater fish, designation of conservation zones.	**Salmon and Freshwater Fisheries Act 1975:** Provides details of prohibition of certain methods of taking and destroying fish, fishing licenses and enforcement.	**Climate Change levy:** The levy rate varies for different fuels and commodities in kilowatt-hours (kWh) for gas and electricity and kilograms for all other taxable commodities. Covers coal, coke, electricity consumption and production, natural gas.	**Water Pollution Act 1993:** Provision for the protection of inland and coastal waters from pollution; to control deposits in the sea; and for connected purposes; a licensing system for discharges, deposits and vegetation in rivers, and defines offenses in respect of water pollution.	
Conservation of Habitats and Species Regulations 2017 (SI 2017/1012) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (SI 2017/1013). These regimes implement the Edu Habitats Directive (92/43) and remain in place following the UK's departure from the EU.	**Packaging Waste Regulations 2007:** Obliges companies to recover and recycle packaging waste to meet national targets. Issues certificates providing evidence that waste packaging material has been recycled into a new product. For obligated producers (annual turnover > GBP 2 million, handle 50 tons or more of packaging in a calendar year).	**Carbon Reduction Commitment Efficiency Scheme:** Allowance trading system of CO2/carbon. Large retail organizations and public sector organizations that are not covered by the EU ETS or the CCA, who used more than 6000 mWh of electricity in 2008. Both civil and criminal penalties for non-compliance apply.	**Environmental Protection Act 1990:** Provisions for the improved control of pollution arising from certain industrial and other processes; waste collection and disposal, and imposes duties to keep public places clear of litter and clean; radioactive substances; genetically modified organisms; to control the burning of crop residues; to make provision in relation to financial or other assistance for purposes connected with environment.	
Wildlife and Countryside Act 1981: Prohibits certain methods of killing or taking wild animals, restricts the introduction of certain animals, makes provisions for nature conservation an national parks including the protection of animals and plants		**Energy Act 2013:** Provides the legislative framework for "decarbonization" of energy-producing plants and delivering secure, affordable and low carbon energy. It gives the Secretary of State a power to set or amend a decarbonization target range, which is a target range for the level of carbon intensity of the electricity generation sector in the United Kingdom.	**Pesticides Act 1998:** Provisions for the powers to make regulations concerning pesticides and in respect of the enforcement of provision relating to the control of pesticides.	
Other fees and taxes				
Water regulator fees	Aggregates levy	Climate Change Levy	Air passenger duty	
	Fishing licenses	Duty on hydrocarbon oils	Vehicle excise duty	
	Landfill tax			

Source: Credit Suisse

Using a combination of ECOLEX and OECD data, we categorize UK legislation by each driver of biodiversity in **Table 3** and show that legislation can range from the Water Act and fishing licenses to climate change legislation, pesticides and air passenger duty.

How are countries responding?

The Aichi assessment is a good proxy for regulatory development and implementation, but it struggles to show a tangible indication on the impact of biodiversity regulations. Given the wide-ranging legal and regulatory patchwork, as we show with the UK example, a comprehensive analysis on the effectiveness of implementation needs to assess a range of variables. To provide a better indication of country-level biodiversity regulation and the risk it poses to companies and investors, we have compiled the following composite of metrics to create a comparable basis for country-level observations.

We can use a range of explicit regulatory metrics and environmental performance metrics. In **Table 4**, we identify nine metrics that we have selected from the Yale 2022 Environmental Performance Index (EPI) that can be used to assess the implementation of related regulations that were either explicitly derived with reference to regulatory oversight or infer regulatory performance. For example, the first two metrics are the total percentage of land and marine area that have been protected by law, the Biodiversity Habitat Index measures the connectedness of the areas or, in other words, how effectively the areas have been chosen to promote biodiversity, and the Marine Trophic Index indirectly relates to the performance of regulation because it measures the level of overfishing, which is itself controlled by regulation.

We also consider the use of pesticides: while there is already a relatively comprehensive set of regulations to control the use of pesticides,

Table 4: Assessment indicators from the Yale EPI that relate to the strength and effectiveness of biodiversity regulation

	Protected areas		Assessment of protected areas				Resource use	Pollution	
	Terrestrial	**Marine**	**Representation**	**Ecosystem health**	**Effective-ness**	**Effective-ness**		**Pesticides**	**Fertilisers**
Metric			Protected Areas Representativeness Index	Biodiversity Habitat Index	Species Protection Index	Species Habitat Index	Marine Trophic Index	Sustainable Pesticide Use	Sustainable Nitrogen Management Index
Description	% of land protected	% of marine areas protected	Extent that biodiversity is considered in the protected area	Effects of habitat loss and degradation on biodiversity	How adequately protective areas protect species	Measures proportion of habitat that remains intact for each species	Measures how a country may be overfishing or fishing down the food chain between tropic levels.	Sustainable pesticide use leverages two inputs — pesticide risk score and pesticide application rates	Measures relationship between nitrogen use efficiency and nitrogen yield
Scoring	17% target	10% target	1 indicates protected areas, captures biodiversity and 0 represents no biodiversity protection	1 indicates no habitat loss and biodiversity intact	Average % of suitable habitat for species that is within protected areas. Higher %, more protected.	% of suitable habitat that remains relative to 2001		Global optimal is 1kg/ha	0 means optimal application
Australia	15%	33%	0.2	0.6	73	99.2	0.006591	0.6	0.7
Brazil	14%	26%	0.2	0.5	70	96.4	0.008543	2.3	0.5
China	1.4%	0%	0.04	0.4	3	98.1	0.004127	2.9	0.7
EU	16%	18%	0.2	0.4	78	98.9	0.007163	2.4	0.6
India	0%	0%	0.0	0.3	0	99.1	0.010562	2.5	0.9
UK	17%	78%	0.2	0.4	32	99.5	0.013851	2.9	0.6
USA	11%	15%	0.1	0.5	45	98.9	0.009040	2.2	0.4

Source: Yale EPI, Credit Suisse

concerns are growing as new research and understanding of the risk of pesticides emerges. Increasingly, countries are using the precautionary principle, reflecting the level of concern. The EU has recently introduced a new policy to reduce the impact of toxic chemicals and has already banned the use of certain pesticides called neonicotinoids.

Country-level assessment indicators reiterate the complexities of reviewing the effectiveness of biodiversity regulation. China and India receive the lowest scores under these nine indicators. This is instructive because, under the United Nations CBD assessment of Aichi progress, China was in the top five of country reports assessed as being on track. However, when we look more closely at the 20 targets, China has not made sufficient progress on Target 6 (sustainably harvesting fish stocks), Target 9 (managing invasive species) and Target 12 (improving the extinction rate). The most notable discrepancy between the two assessments is Target 11 (protected area coverage).

Under the Aichi assessment, China is determined to be on track to achieving the target, with 14% of terrestrial land protected. However, the Yale EPI assessment finds that only 1.4% is protected. We believe this is attributable to differing methodologies for calculation of total land, whereby the EPI assesses the proportion of each biome in a country that lies within a protected area, giving greater weight to biomes that are relatively rare within a country, and giving less weight to prevalent biomes before aggregating the proportions. The inference is that the majority of protected land in China is relatively common land that fails to target unique biomes.

Most countries are not delivering on biodiversity outcomes. Looking at the broader sample of countries, we see that while most had either achieved or were on track to achieve the Aichi Target 11 for the minimum protected area, they do not perform highly on the metrics that assess the objective outcomes. All countries perform poorly on the Protective Areas Representativeness Index, which looks at the extent to which biodiversity is considered and captured in protected areas.

> “
> ## Most countries are not delivering on biodiversity outcomes

Metrics can be misleading at the country level. For species protection, Australia, Brazil and the EU have designated protected areas that cover the greatest proportion of suitable habitat for species. However, when it comes to assessing how that habitat has changed since 2001, Brazil has lost the most of all countries. Looking at the other drivers of biodiversity outcomes, such as pollution from agriculture, only Australia appears to be determined to use pesticides sustainably. However, we wonder whether this is driven more by adopting large protected areas in the country rather than a reduction in the total amount of pesticides used. Finally, all sample countries are deemed to be unsustainably managing nitrogen use in agriculture.

Photo: Martin Herzog, iStock

Future challenges and opportunities

The need for investors to incorporate biodiversity risk into their analysis is rapidly growing. As a result, several reporting and standard-setting bodies have emerged with the aim of assisting in this process. We believe that the so-called LEAP framework (locate, evaluate, assess, prepare) developed by the Taskforce for Nature-related Financial Disclosures (TNFD) may well become the standard for investors when assessing nature-related risks and opportunities. This is needed to ensure that nature-based investments do indeed triple by 2030 as estimated by the United Nations and increase four-fold by 2050 to USD 536 billion per year in order to meet global climate, biodiversity and land conservation targets.

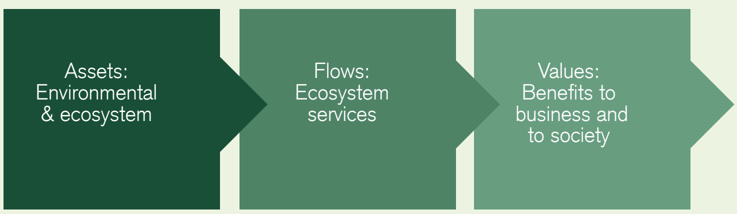
Developing measurement concepts and tools

Investors use the term natural capital to describe the value of nature. Nature consists of environmental assets that provide flows or benefits to people and the economy (see **Figure 1**). The stock can be both renewable and non-renewable natural resources such as soils, minerals, air, water and all living things. But nature does not exist in silos. Instead, all aspects of nature are interlinked complexes or ecosystems. The flows come from where both the biotic natural assets (living things such as plants, animals and bacteria) and abiotic natural assets (non-living things such as water, soil and atmosphere) interact to provide a range of ecosystem services.

Ecosystem services describe the types of values and benefits provided by nature. Ecosystem services are the benefits that humans derive from ecosystems and are classified into four categories: provisioning, cultural, regulating and supporting services.

- Provisioning services represent the contributions to benefits that are extracted or harvested from ecosystems (e.g. timber and fuel wood in a forest, freshwater from a river).
- Cultural services are the experiential and intangible services related to the perceived or actual qualities of ecosystems where their existence and functioning contribute to a range of cultural benefits (e.g. the recreational value of a forest or a coral reef for tourism).
- Regulating and supporting services result from the ability of ecosystems to regulate biological processes and to influence climate, hydrological and biochemical cycles, and thereby maintain environmental conditions beneficial to individuals and society. Provisioning services are dependent

Figure 1: The relationship between natural capital and ecosystem services



Source: TNFD, Credit Suisse

on these regulating and supporting services (e.g. the provision of freshwater depends on the ability of forests to absorb carbon and regulate climate change).

In **Table 1**, we show the complete list of ecosystem services under the four categories.

Reporting and disclosure regimes

Biodiversity-related corporate reporting is developing fast and there is ongoing work to create harmonization:

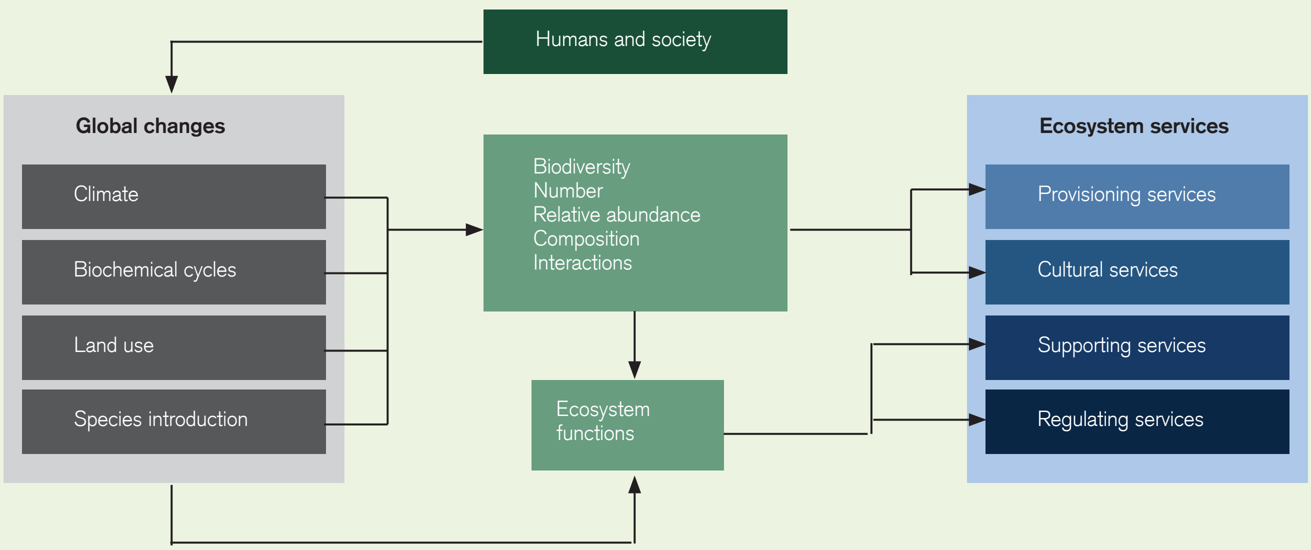
- The Science Based Targets Network (SBTN) has issued initial guidance for nature prior to publishing integrated science-based targets for all aspects of nature, including biodiversity. The Capitals Coalition Align Project aims to support businesses and other stakeholders in developing a standardized approach to biodiversity measurement and the partnering Transparent Project is developing a standardized natural capital accounting and valuation methodology. The Taskforce on Nature-related Financial Disclosures (TNFD) seeks to provide specific sector-agnostic recommendations for reporting and disclosures. Finally, in November 2021, the International Financial Reporting Standards (IFRS) Foundation announced the formation of a new International Sustainability Standards Board (ISSB) to develop a comprehensive global baseline of high-quality disclosure standards on climate and other sustainability issues to meet investors' information needs, building on the work of existing investor-focused reporting initiatives.
- GRI – biodiversity: The Global Reporting Initiative provides disclosure guidance on biodiversity under its 2016 GRI304 biodiversity report. It has four key principles associated with the location of company operations and assessment of impacts on protected areas and species. We show the details in **Table 2**. GRI are currently in the process of revising GRI304 to reflect best practice on biodiversity management and to align with the United Nations CBD.
- ISSB and CDSB biodiversity guidance: The standards originally established by the Climate Disclosure Standards Board (CDSB) and now consolidated into the IFRS and the International Sustainability Standards Board (ISSB) set requirements for disclosures on other sustainability-related matters in corporates' financial reports, including risks

Table 1: Examples of the types of ecosystem services that nature provides

Provisioning	Cultural	Supporting	Regulating
Food, fiber and fuel Genetic resources Biochemicals Fresh water	Spiritual & religious values Knowledge system Education and inspiration Recreation and aesthetic values Sense of place	Primary production Provision of habitat Nutrient cycling Soil formation and retention Air filtration Water cycling	Invasion resistance Herbivory Pollination Seed dispersal Climate regulation Pest regulation Disease regulation Natural hazard protection Erosion regulation Water purification

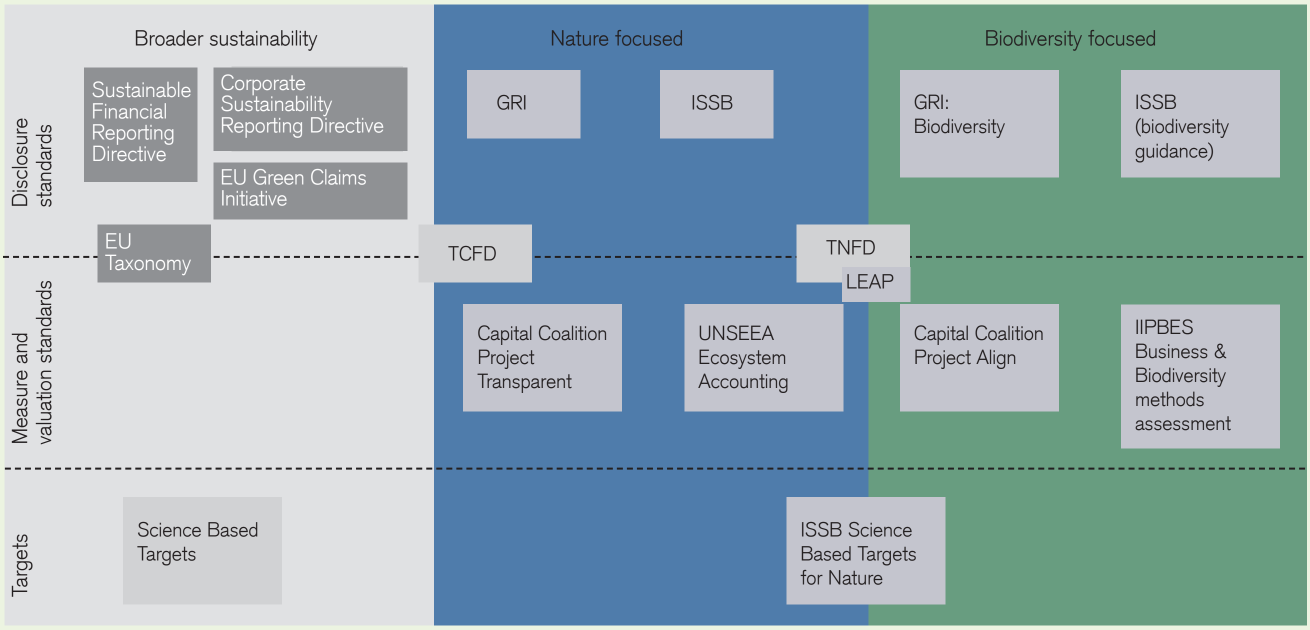
Source: Ecosystem Millennium Assessment, Credit Suisse

Figure 2: How biodiversity interacts with drivers to deliver ecosystem services



Source: Credit Suisse

Figure 3: Setting out the array of key global sustainability, nature and biodiversity standards



Source: Credit Suisse

Table 2: GRI disclosure principles for biodiversity under GRI304

Disclosure principle		Information provided
304-1	Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.	For each operational site in or adjacent to protected areas and areas of high biodiversity value: Geographic location, position in relation to the area, the type and size of operation, biodiversity value characterized by the attribute of the area and/or by protected status.
304-2	Significant impacts of activities, products, and services on biodiversity.	1) Nature of significant direct and indirect impacts on biodiversity including construction, manufacturing, pollution, invasive species, reduction of species, habitat conversion and changes in ecological processes. 2) Significant direct and indirect positive and negative impacts including species, habitat, duration of impacts and reversibility of impacts.
304-3	Habitats protected or restored.	1) Size and location of all habitat areas protected or restored, and whether the success of the restoration measure was or is approved by independent external professionals. 2) Status and condition of the areas. 3) Standards, methodologies and assumptions used.
304-4	IUCN Red List species and national conservation list species.	Total number of IUCN Red List species and national conservation list species with habitats in areas affected by the operations of the organization, by level of extinction risk.

Source: Global Reporting Initiative

relating to biodiversity on an organization's strategy, financial performance and condition within the mainstream reporting. The six reporting requirements are (1) Governance, (2) Management environmental policies, (3) Strategies and targets, (4) Risks and opportunities, (5) Sources of environmental impact, performance and comparative analysis, and (6) Outlook. The CDSB framework for climate reporting was integrated into the Task Force on Climate-related Financial Disclosures (TCFD) and the same approach is currently being undertaken with the Taskforce on Nature-related Financial Disclosures (TNFD) for biodiversity.

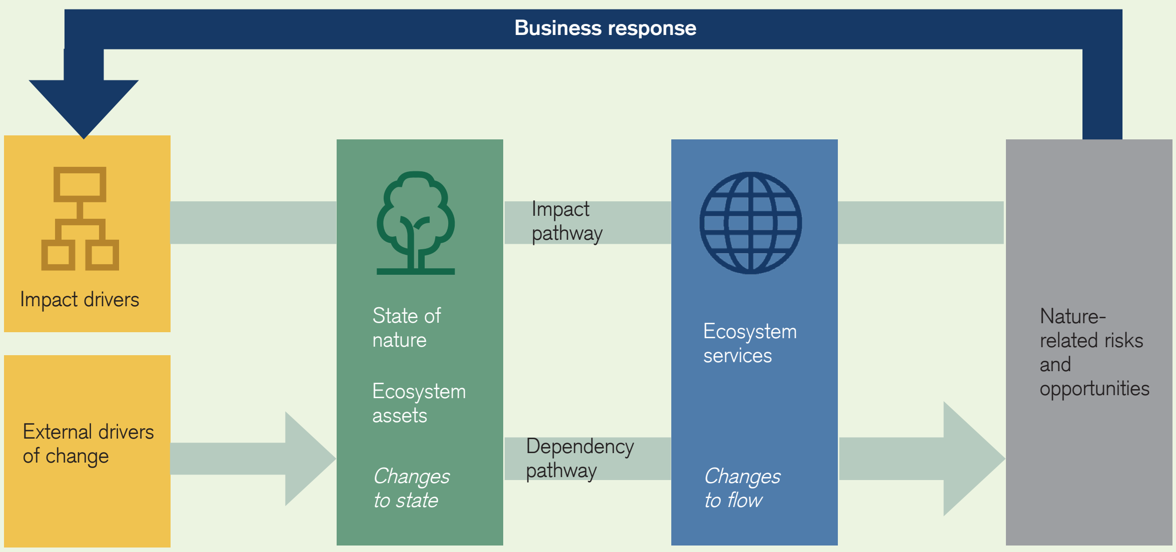
- Natural Capital Protocol (NCP) is a decision-making framework that enables organizations to identify, measure and value their direct and indirect impacts and dependencies on natural capital. Traditionally the value of natural capital has, for the most part, been excluded from decision-making. The NCP responds to this gap by offering an internationally standardized framework for the identification, measurement and valuation of impacts and dependencies on natural capital. The NCP does not prescribe specific tools or methods, but rather focuses on the approach to organizational decision-making.

  1. Integration into TNFD: The NCP framework consists of four stages and nine steps that help corporates to integrate the value of natural capital into their organizational processes. Stage three – to measure and value impacts and dependencies – assesses changes and integrates into stages E and A of the LEAP assessment as explained later in this chapter.
  2. The Align Project is developing a suite of methods, indicators and criteria for biodiversity measurement (evaluation) and valuation tools.
  3. The Transparent Project is the sister project to Align and is developing standardized natural capital accounting and valuation principles for business on air, sea, water and land. These are the four realms that also relate to changes in impact drivers affecting biodiversity.

The SEEA Ecosystem accounting method records physical stocks and flows of environmental assets. The United Nations System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA) is designed to record physical stocks and flows in environmental assets, as well as changes in those stocks and flows over time. It is a spatially based, integrated statistical framework for organizing biophysical information about ecosystems, measuring ecosystem services, tracking changes in ecosystem extent and condition, valuing ecosystem services and assets and linking this information to measures of economic and human activity. Five different accounts are used to measure different aspects of ecosystems and their relationship to the economy in physical (1–4) and monetary terms (5–6) (see **Figure 6)**.

1. Ecosystem Extent accounts record the total area of each ecosystem, classified by type within a specified area (ecosystem accounting area). Ecosystem extent accounts are measured over time in ecosystem accounting areas (e.g. nation, province, river basin, protected area, etc.) by

Figure 4: Impacts and dependencies



Source: The Align Project, Credit Suisse

ecosystem type, thus illustrating the changes in extent from one ecosystem type to another over the accounting period.

2. Ecosystem Condition accounts record the condition of ecosystem assets in terms of selected characteristics at specific points in time. Over time, they record the changes to their condition and provide valuable information on the health of ecosystems.

3 and 4. Ecosystem Services flow accounts (physical and monetary) record the supply of ecosystem services by ecosystem assets and the use of those services by economic units.

5. Monetary Ecosystem Asset accounts record information on stocks and changes in stocks (additions and reductions) of ecosystem assets. This includes accounting for ecosystem degradation and enhancement.

In July 2022, the IPBES approved the Assessment Report on the Diverse Values and Valuation of Nature. Over 50 valuation methods have been identified to date from over 13,000 scientific studies, categorized as (1) nature-based (e.g. ecosystem services and biodiversity mapping), (2) statement-based (e.g. stated preferences and Q method); (3) behavior-based (e.g. revealed preference and livelihood assessment), and (4) integrated valuation (e.g. integrated modelling and participatory mapping). IPBES found that transformative change is needed and that addressing the global biodiversity crisis relies on shifting away from predominant values that currently over-emphasize short-term and individual material gains to nurturing sustainability-aligned values across society.

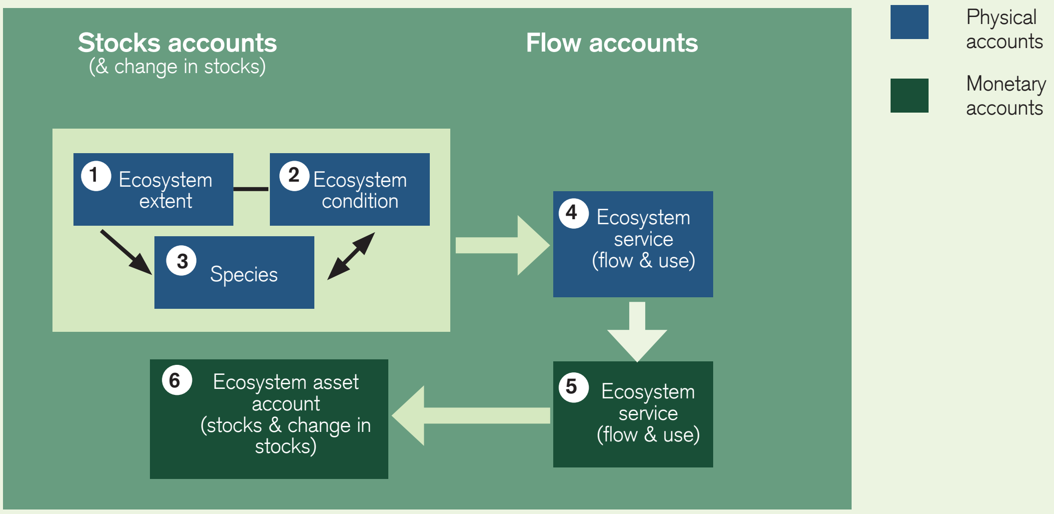
LEAPing into TNFD

The Taskforce on Nature-related Financial Disclosures (TNFD) was created to unify and standardize nature-based disclosures. It found that there are over 3,000 nature-related metrics already in use today by standard-setting, policy-making and regulatory bodies, and in major scientific reference reports. The lack of standardization of nature-related metrics limits corporate and financial institution measurement, management and reporting of nature-related risks and opportunities, and poses challenges for providing comparability across and within sectors.

The TNFD complements the Task Force on Climate-related Financial Disclosures (TCFD) to factor nature into financial decisions. It aims to give investors, lenders, and insurers a holistic picture of nature-related risks and dependencies. The framework is designed to meet the demands of a range of stakeholders in factoring nature into financial and business decisions. It focuses on assessing impacts on nature, i.e. how an organization's activities positively or negatively impact nature from the "inside out," and dependencies on nature, i.e. how nature positively or negative affects an organization's financial performance from the "outside in."

The TNFD considers impacts and dependencies across four realms, 34 biomes, 13 environmental assets and 25 ecosystem services. Society interacts with nature across all four realms of land, freshwater, marine and atmosphere. People, including corporates and financial institutions, depend on and have an impact on nature. As such, society contributes to, and is affected by, the main drivers of nature.

Figure 5: Setting out the array of global sustainability, nature and biodiversity standards



Source: United Nations, Credit Suisse

TNFD created LEAP to understand, assess and report on nature-related risks and opportunities. In response to calls for simple and accessible guidance, the TNFD has developed an integrated assessment process that forms the analytical component of the broader financial disclosure guidance, which will eventually be published at the sector level. In **Figure 6**, we show the structure of the LEAP assessment, which requires companies to:

- Locate their assets to determine which of them interface with biomes and ecosystems, and thus prioritize areas that may be of higher risk.
- Evaluate the relevant dependencies and impacts on nature in relation to the state of nature and ecosystem services.
- Assess the financial risks and opportunities from these impacts and dependencies.
- Prepare to report the findings in the TNFD disclosure framework based on materiality.

From an investor perspective, the "Locate" step is challenging at this stage: The TNFD acknowledges that financial institutions face unique challenges when it comes to understanding and assessing the relationship of their investee companies' assets with nature. Aside from the disclosure constraint in respect of the precise spatial coordinates of companies' operational assets, these are clearly outside of the operational bounds of investors and may have a multitude of touchpoints. For the moment, the TNDF is focusing on guidance assisting corporate entities to undertake "Locate-specific" analysis.

The TNFD has therefore developed specific guidelines for financial institutions. It first advises that financial institutions engage their investee companies to complete their own corporate-based LEAP and TNFD disclosure to develop location-specific data that can be reviewed by the financial institution. In the absence of this, the TNFD allows user discretion as to how to begin the LEAP assessment. For example, instead of approaching "Locate" at the individual asset level, the financial institution is advised to use existing tools and matrices to determine focus sectors that have a high impact and/or high dependence on nature (L3 and L4). To determine priority areas, investors should consider the intersection of these with their portfolio exposures. Using this, we can then start to dive deeper into the specifics of priority areas and determine what assessment granularity is feasible given the data and level of aggregation.

The TNFD's current priority for investors is to determine the impacts and dependencies of investee companies in portfolios. Earlier in this report, when we discuss "What is causing biodiversity loss?", we note that there are five impact drivers as defined by the United Nations

Figure 6: TNFD's LEAP assessment framework

LOCATE
The interface with nature

L1: Business footprint
Where are our direct assets and operations, and our related value chain (upstream and downstream) activities?

L2: Nature interface
Which biomes and ecosystems do these activities interface with? What is the current integrity and importance of the ecosystems at each location?

L3: Priority location identification
At which locations is our organization interfacing with ecosystems assessed as being low integrity, high biodiversity importance and/or areas of water stress?

L4: Sector identification
What sectors, business units, value chains or asset classes are interfacing with nature in these priority locations?

EVALUATE
Dependencies and impacts

E1: ID of environmental assets and ecosystem services
What are our business processes and activities at each priority location? What environmental assets and ecosystem services do we have a dependency or impact on at each priority location?

E2: ID of dependencies and impacts
What are our nature-related dependencies and impacts across our business at each priority location?

E3: Dependency analysis
What is the size and scale of our dependencies on nature in each priority location?

E4: Impact analysis
What is the size and scale of our nature impacts in each priority location?

ASSESS
Material risk and opportunities

A1: Risk ID & assessment
What are the corresponding risks for our organization?

A2: Existing risks mitigation and management
What existing risk mitigation and management approaches are we already applying?

A3: Additional risk mitigation and management
What additional risk mitigation and management actions should we consider?

A4: Materiality assessment
What sectors, business units, value chains or asset classes are interfacing with nature in these priority locations?

A5: Opportunity ID and assessment
What nature-related opportunities does this assessment identify for our business?

PREPARE
To respond and report

Strategy and resource allocation

P1: Strategy and resource allocation
What strategy and resource allocation decisions should be made as a result of this analysis?

P2: Performance
How will we set targets and define and measure progress?

Disclosure

P3: Reporting
What will we disclose in line with the TNFD disclosure recommendations?

P4: Presentation
Where and how do we present our nature-related disclosures?

Source: TNFD

CBD and the IPBES. Under the LEAP assessment, the TNFD prompts companies to assess how they themselves contribute to or affect those drivers. On the other hand, dependency analysis considers the extent to which a business activity is dependent on an aspect of nature. This represents the concept of "double materiality." Based on this, if an impact driver were to change externally, how exposed are companies if the natural capital no longer underpins those business activities. This comes back to the relationships that were defined in the Capital Coalition Align project, specifically how a company can have an impact or depend on nature, and how this flows through to the state of nature and ecosystem services and ultimately creates nature-related risks and opportunities.

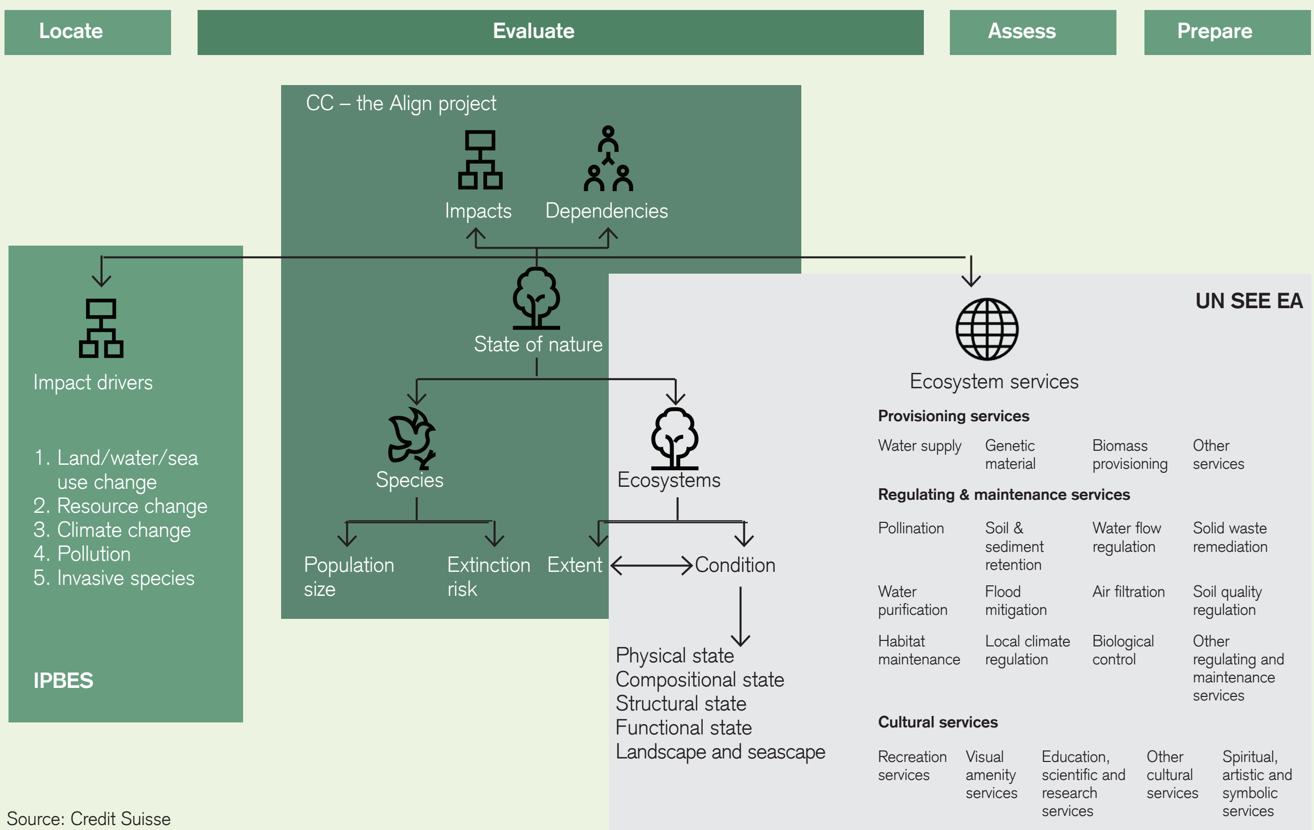
So far, we have identified a complex array of nature regimes and principles, but how do they all fit into the TNFD? In the previous section on Measurement, Validation and Disclosures regimes, we outlined a number of the complex arrays of different biodiversity, nature and sustainability-related regimes that have been developed to date. Although, at first glance, they may appear to be separate from, or in addition to the TNFD, we find that the principles of some of them have been incorporated into the TNFD and can be used to help companies better understand the new disclosure approach and standards.

In **Figure 7**, we show the work by the IPBES on impact drivers, the Capital Coalition's Align Project and the United Nations SEE EA have been incorporated into the TNFD framework under the "Evaluate" part of the LEAP assessment framework.

Mobilizing conservation finance

Investments in nature-based solutions (NbS) need to triple by 2030 and increase four-fold by 2050 in order to meet global climate, biodiversity and land conservation targets (United Nations). Based on findings in the United Nations Environment Programme's State of Finance for Nature report released in 2021, nature-based investments stood at just USD 133 billion in 2020, with public funds making up 86% of that spending. Two-thirds of public spending is currently spent on forest restoration, peatland restoration, regenerative agriculture, water conversation and natural pollution control systems, while the remainder is spent on protection of biodiversity and landscapes. The private sector accounts for a comparably small USD 18 billion per year, spanning biodiversity offsets, supply chains, impact and philanthropic investments. To keep global warming below 2.0°C, NbS investments need to reach USD 536 billion per year by 2050, with most of the increase in reforestation and/or afforestation given the massive global footprint of forests as well as silvopasture

Figure 7: Mapping key institutions and resources to the LEAP framework of the TNFD



Source: Credit Suisse

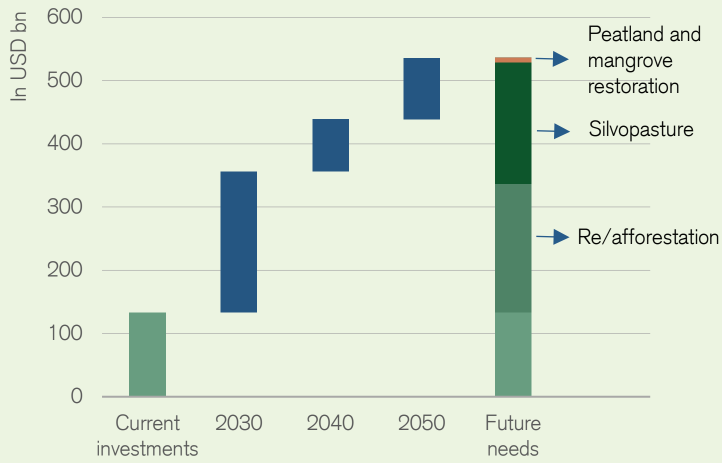
(planting trees on agricultural land). While both public and private spending need to increase, mobilizing private financing will clearly be one of the central challenges in the coming years.

Governments are recognizing that NbS investments not only help to reduce emissions, but they also boost resilience to the impacts of the changing climate. We note that 66% of governments have already committed to restoring or protecting ecosystems in their Nationally Determined Contributions (NDCs), 104 governments have included natural ecosystems in their adaptation plans, and 27 governments have described NbS in their mitigation targets. Additionally, we have already seen an increase in conservation in post-COVID green recovery stimulus packages. This includes:

- Two landmark laws have been proposed to address ecosystem restoration in the EU: Recognizing that growing demand for natural resources as result of intensive agriculture, urban infrastructure and other human activities is leading to rapid decline in Europe's natural areas, with over 80% of habitats in poor condition (Conservation status of habitats under the EU Habitats Directive, 2021), the EU launched two strategies in 2020 as part of the European Green Deal – "The EU Biodiversity Strategy for 2030" and "Farm to Fork Strategy" to address this challenge. In June 2022, the European Commission proposed two landmark laws under these strategies with legally binding targets that aim to restore damaged ecosystems (Nature Restoration Law) and halve the use of chemical pesticides by 2030 (Regulation on the Sustainable Use of Plant Protection Products). According to the commission, the Nature Restoration Law builds on existing legislation, but covers all ecosystems. It will also benefit from substantial funding, with around EUR 100 billion to be available for biodiversity spending, including restoration.
- In the USA, the recently passed Inflation Reduction Act includes USD 20 billion in funding for advanced agriculture conservation efforts, which specifically ties funding with sustainable farming practices such as no tillage, planting of cover crops, etc. In addition, there is a total of USD 7.5 billion allocated for land, including grants for conservation programs on federal and non-federal land, and for climate resilience.

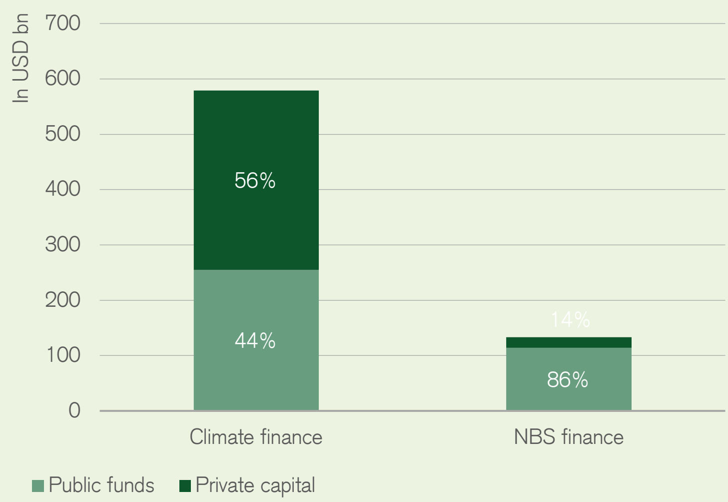
Investors are also becoming more aware of conservation financing as an investment opportunity. A 2021 survey by the Coalition for Private Investment in Conservation (CPIC) found that 70% of investors are planning to substantially increase investments in conservation in 2021 versus 2020. Similarly, project developers are also seeking more funding, aiming to raise 85% more for conservation projects in 2021 than they did in 2020. With the voluntary carbon market ramping up, nature-based solutions such as reforestation/afforestation projects now account for 45% of the total credits issued since 2019. Partly driven by net-zero considerations, we see that high-quality projects are also increasingly sought after due to a shift in demand preference from avoidance to removal credits and because

Figure 8: Current vs. future annual investment needs* in NbS



* Based on an "immediate action scenario," in which the global community is assumed to act now to halt climate change at <2.0°C
Source: United Nations Environment Programme's State of Finance for Nature 2021 report

Figure 9: Climate finance vs. NbS finance (2017–18 average)



Source: United Nations Environment Programme's State of Finance for Nature 2021 report

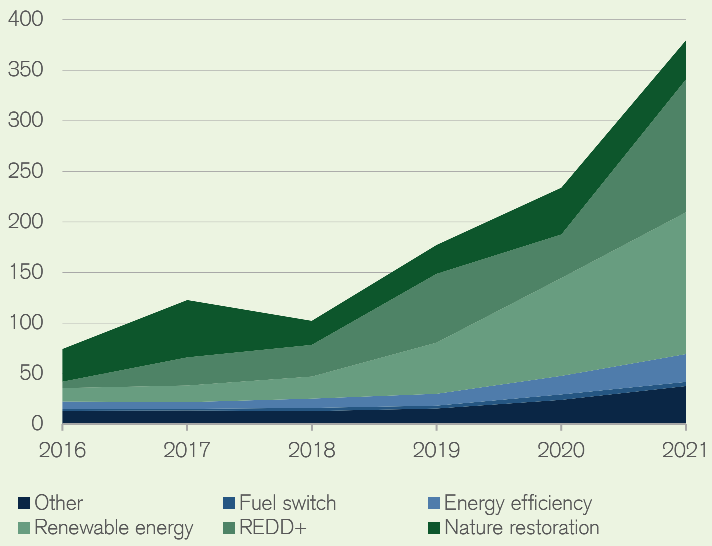
of non-carbon benefits. In our conversations, biodiversity and NbS investment opportunities in the context of voluntary carbon markets are among the most-discussed topics this year. The growth in new measuring and monitoring technologies, nature-related disclosure requirements (e.g. the TNFD disclosure framework discussed above) and an increasing focus on impact among sustainability-minded investors/funds are all expected to drive investments in conservation in the coming years.

Market interest in biodiversity credits is at a high level. Similar in concept to carbon credits, which deliver a measurable unit of carbon emissions avoided or removed from the atmosphere, a biodiversity credit would represent a unit of biodiversity that is protected or restored. From a project-development perspective, there is a clear need to price in such differentiators as the voluntary carbon market today remains highly carbon-centric and does not reflect, at least on a comparable and consistent basis, non-carbon attributes such as social and biodiversity benefits. There is also increasing demand for nature-based investments from corporates as more and more companies are setting conservation targets along with emissions goals and are focused on supply-chain issues such as "avoided deforestation." Complementary to a potentially USD 50–100 billion voluntary carbon market, a well-designed biodiversity credit scheme could potentially unlock significant private financing in conservation investments.

However, to ensure confidence in market integrity, several challenges need to be addressed:

- Agreement on a common definition for a biodiversity credit: There is no widely used set of standards or agreement on what defines a unit of biodiversity credit, how the net positive impact of an investment should be measured and comparability across projects and regions.
- Measurability: Digital innovation is critical for improving conservation impact measurement through remote sensing and artificial intelligence. However, there are concerns that such metrics only give a partial picture of the range of the effects on biodiversity and may not be comparable at larger scales. Monitoring costs for biodiversity are also likely to be higher than for carbon credits given the complexity of factors involved.
- Corporate claims and use case: Perhaps most important to market integrity is ensuring that biodiversity credits deliver outcomes that are additional and do not divert companies' efforts from reducing or eliminating their negative impacts on biodiversity in the first place. As such, how companies claim "credit" for the purchase of these biodiversity credits requires monitoring.

Figure 10: Historical issuance of voluntary carbon credits by type



Source: Trove Research, Credit Suisse

In summary: This report outlines that a healthy biodiversity is crucial to sustain life on earth. The economic rationale for this appears obvious, too, in our view as over half of the world's GDP is moderately or highly dependent on nature. However, current consumption and production trends, especially when coupled with the expected further increase in the world's population during the next few decades, are likely to put above- and below-ground biodiversity at serious risk, with significant economic consequences. For example, the loss of ecosystem services due to land use change alone is estimated to cost USD 4.3–20.3 trillion (Constanza et al, 2014).

We believe that improving the state of the world's biodiversity requires the adoption of a wide range of solutions. These mostly focus on reducing the intensity of production processes so that humanity's ecological footprint no longer exceeds our planet's biocapacity. Solutions that in our view need to be adopted or accepted include more sustainable farming practices, including a reduction in the usage of non-organic chemicals, tighter regulation and reporting by corporates and investors, the development of biodiversity-related carbon credits and a wide adoption of nature-based solutions, including the elimination of deforestation. We look forward to exploring each of these topics further in future Center for Sustainability publications.

Photo: Crystal Bolin Photography, iStock

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ESG-related risks in a portfolio context need to become an integral part of the investment process because they can impact growth, profitability, or the cost of capital in the long term. ESG insights need to be combined with traditional fundamental analysis in order to obtain a comprehensive picture of a company and implement better-informed investment decisions.

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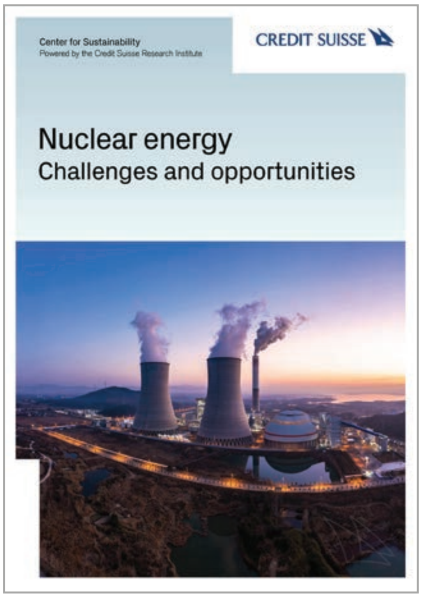

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