2024

Biodiversity 101

This is a primer that contextualises the latest research on biodiversity and nature, with the goal of providing essential knowledge to support discussion and meaningful action.

2150

What is Biodiversity?

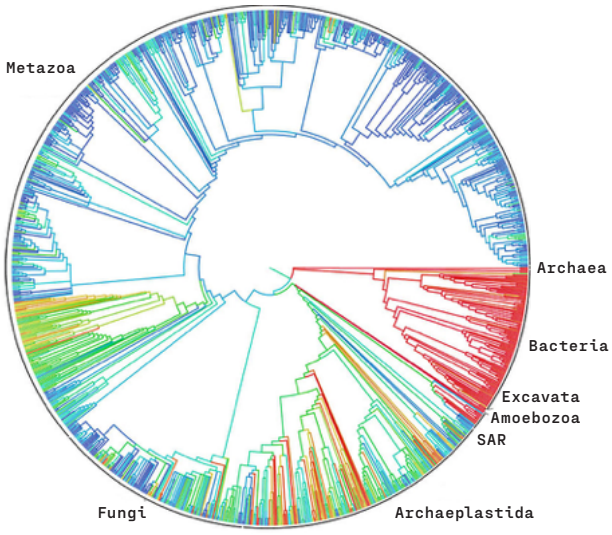
Biodiversity is "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

Species diversity is the number of different species present in a given area and their relative abundance.

Genetic diversity is the diversity of genetic characteristics within a species.

Ecosystem diversity is the variety of ecosystems within a region.

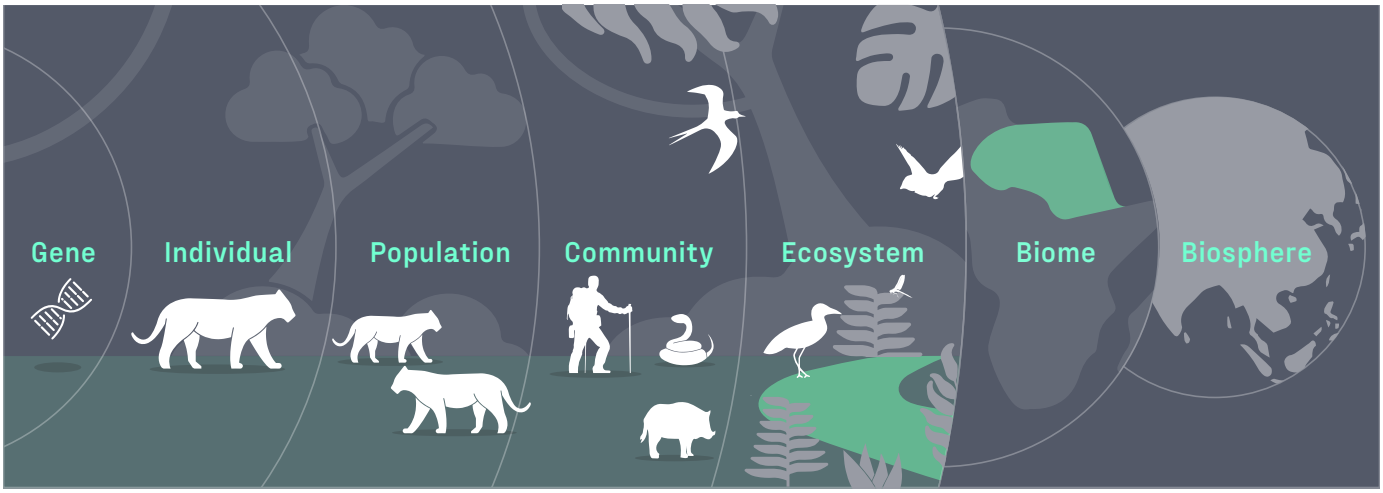
Source: The Convention on Biological Diversity (CBD)



Circular view of species diversity that includes branches on the tree of life associated with at least 500 species.

Source: Elizabeth Pennisi (21st Sep 2015) "First comprehensive tree of life shows how related you are to millions of species", Science.

An **ecosystem** is a dynamic complex of plant, animal, and micro-organism communities and their non-living environment, interacting as a functional unit. Ecosystems together form the Biosphere, which encompasses all living organisms.



Gene
A small section of DNA that acts as the basic physical and functional unit of heredity.

Individual
A single organism of a specific species.

Population
Organisms of a species living together in a group at a particular place.

Community
An interacting group of various species in a common location.

Biome
A distinct geographical region characterised by specific climate, vegetation, and animal life.

Biosphere
The part of Earth that is occupied by living organisms.

Source: Graphic based on Figure 2.1 from Dasgupta, P. (2021), The Economics of Biodiversity: The Dasgupta Review.

Why is Biodiversity Important?

Biodiversity underpins ecosystem services

Biodiversity is an essential characteristic of stable, resilient, and functional ecosystems, whose processes are vital to all life on Earth, including humans. The human population derives value from biodiversity through ecosystem services. Preserving biodiversity is vital for the sustained delivery of these ecosystem services.

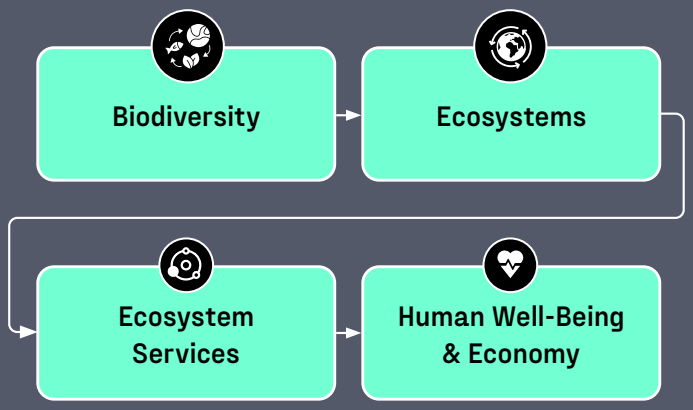
Ecosystem services are the direct and indirect benefits people acquire from ecosystems. They can be grouped as follows:

Provisioning services	Regulating services	Supporting services	Cultural services
Food and fibre	Water purification	Habitat provision	Recreation
Fuel	Pollination	Genetic diversity	Tourism
Freshwater	Erosion regulation	Primary production	Spiritual and religious
Medicinal, biochemical, and genetic resources	Air purification	Nutrient cycling	Intellectual development
	Climate regulation	Soil formation	Artistic and enrichment

Source: OECD, 2019

While ecosystem services and biodiversity are distinct concepts, they are intrinsically linked.

Biodiversity loss has a wide range of consequences on ecosystems' ability to function. Biodiversity is essential to resilient[1], adaptable[2], and productive[3] ecosystems, and the variety of functions and services they provide. Changes in biodiversity can affect the supply of ecosystem services. For example, biodiversity loss is strongly correlated with loss of provisioning and regulating services. Conserving biodiversity maintains healthy ecosystems and the services they underpin.



1 Biodiversity increases the ability of ecosystems to continue functioning in the face of shocks such as fluctuations in the physical environment.

2 Biodiversity increases an ecosystem's capacity to adapt in the face of changing conditions.

3 Biodiversity increases the efficiency with which ecological communities capture essential resources (nutrients, water, sunlight, prey), produce biomass, and decompose and recycle biologically essential nutrients.

Source: Cardinale et al., 2012

Why is Biodiversity Important?

Ecosystem services underpin our economy

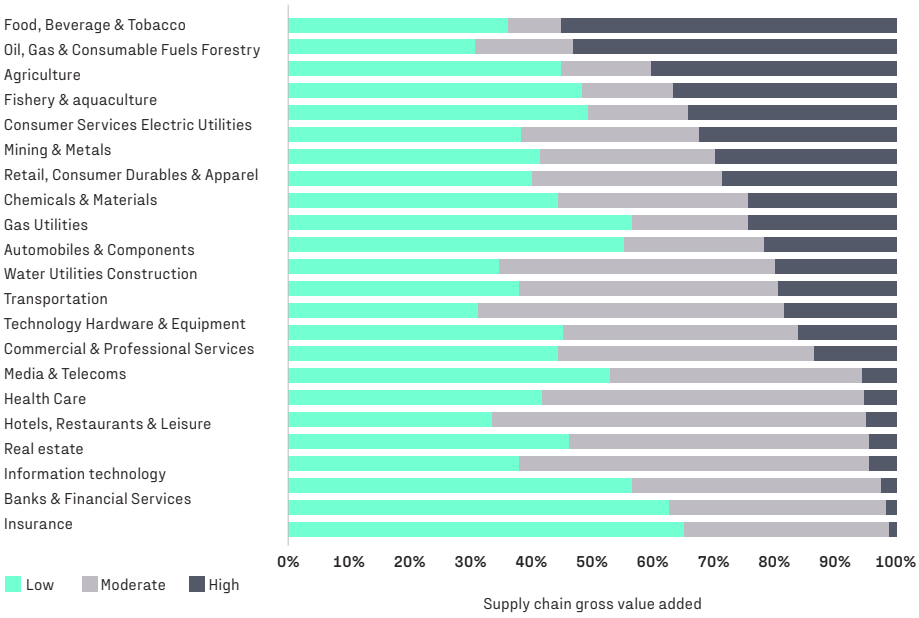
Biodiversity and ecosystem services are essential to our economy, with more than half of global GDP at least moderately dependent on nature. However, these dependencies are systemically undervalued. Novel approaches to value nature, or our natural capital, are emerging.

60%

global GDP that is moderately or highly dependent on ecosystem services

Source: Graphic based on Figure 2 from UBS (2024). Sustainability and Impact Institute. Bloom or bust. Aligning technology and finance to address biodiversity challenges.

Note: Data for 2022. Nature dependence: exposure of economic value generated by business activities to disruption of ecosystem services that underpin them. "High": activities could fail financially due to disruption; "Moderate": activities could experience material reduction in financial returns due to disruption; "Low": activities experience limited material financial effects.



Natural capital accounting is an approach to value the natural assets that underpin ecosystem services.

Natural capital is defined as the *stock* of the world's natural resources (including geology, soil, air, water, and all living things) which combine to yield *flows* that benefit people. These flows include ecosystem services (from living organisms) and abiotic services (from the non-living environment).

Source: Natural capital stocks, flows and values. Graphic based on Figure 1.1 from Natural Capital Coalition (2016). "Natural Capital Protocol".

What is the current condition of biodiversity?

Biodiversity loss is accelerating

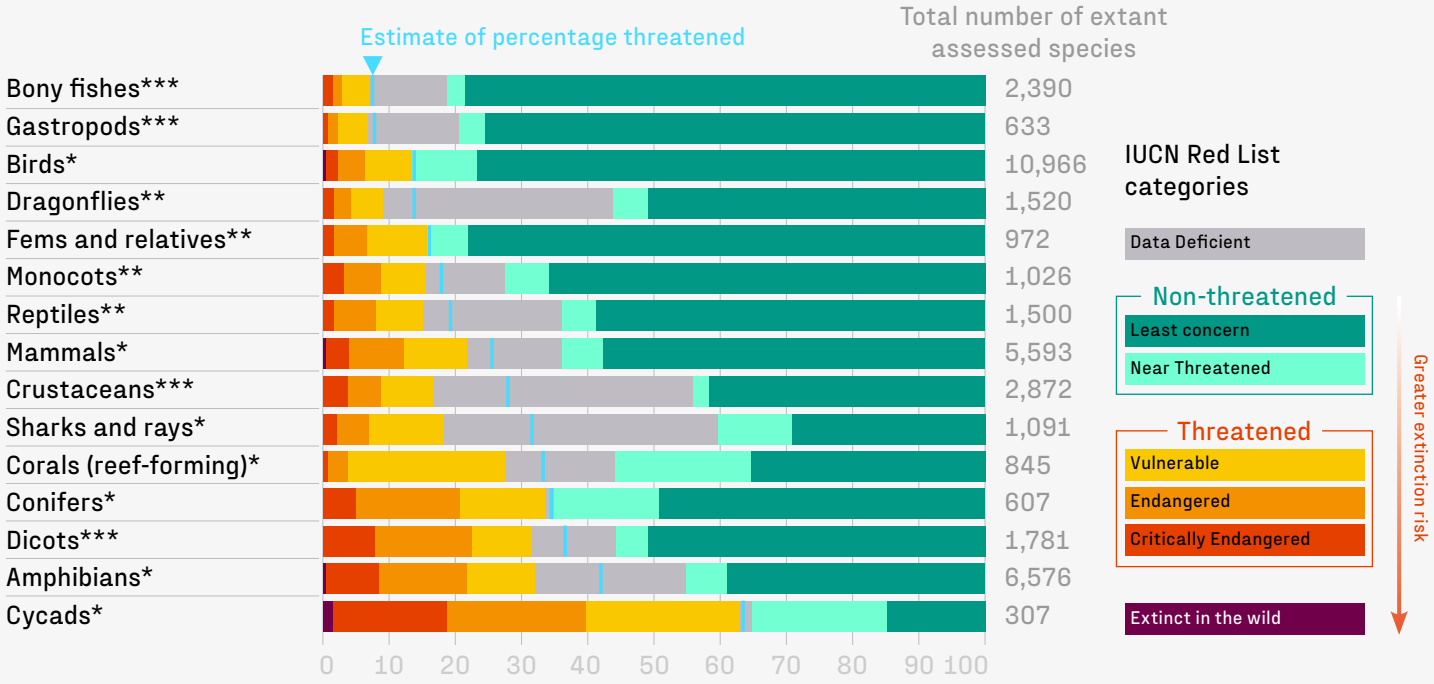
There have been five mass extinctions in Earth's history, coined the "Big Five", the last of which occurred 65.5 million years ago wiping out the Dinosaurs[1]. Given current and predicted rates of species loss, various scientific sources support that the Earth is headed for the sixth mass extinction event[2]. This is the first mass extinction primarily driven by human activity.

1 million
plant and animal species currently at risk of extinction
Source: IPBES, 2019

69%
drop in wildlife population sizes since 1970
Source: WWF, 2022

>1 in 10
vertebrate animal species may be lost by 2100
Source: Strona & Bradshaw, 2022

Current global extinction risk in different species groups



* Comprehensive
** Sampled
*** Selected

Source: Graphic based on Figure SPM 3A from IPBES (2019): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. https://doi.org/10.5281/zenodo.3831673

1. Mass extinctions are typically defined as times when the Earth loses >75% of its species during a relatively short interval of geologic time (< 2.8 million years) (National History Museum, 2023).

2. Ceballos et al., 2017; Barnosky et al., 2011; Kolbert, 2014.

What is the current condition of biodiversity?

Ecosystem services are in decline

Over the past 50 years, we have seen declines in 14 of 18 globally analysed ecosystem services, partially driven by biodiversity loss.

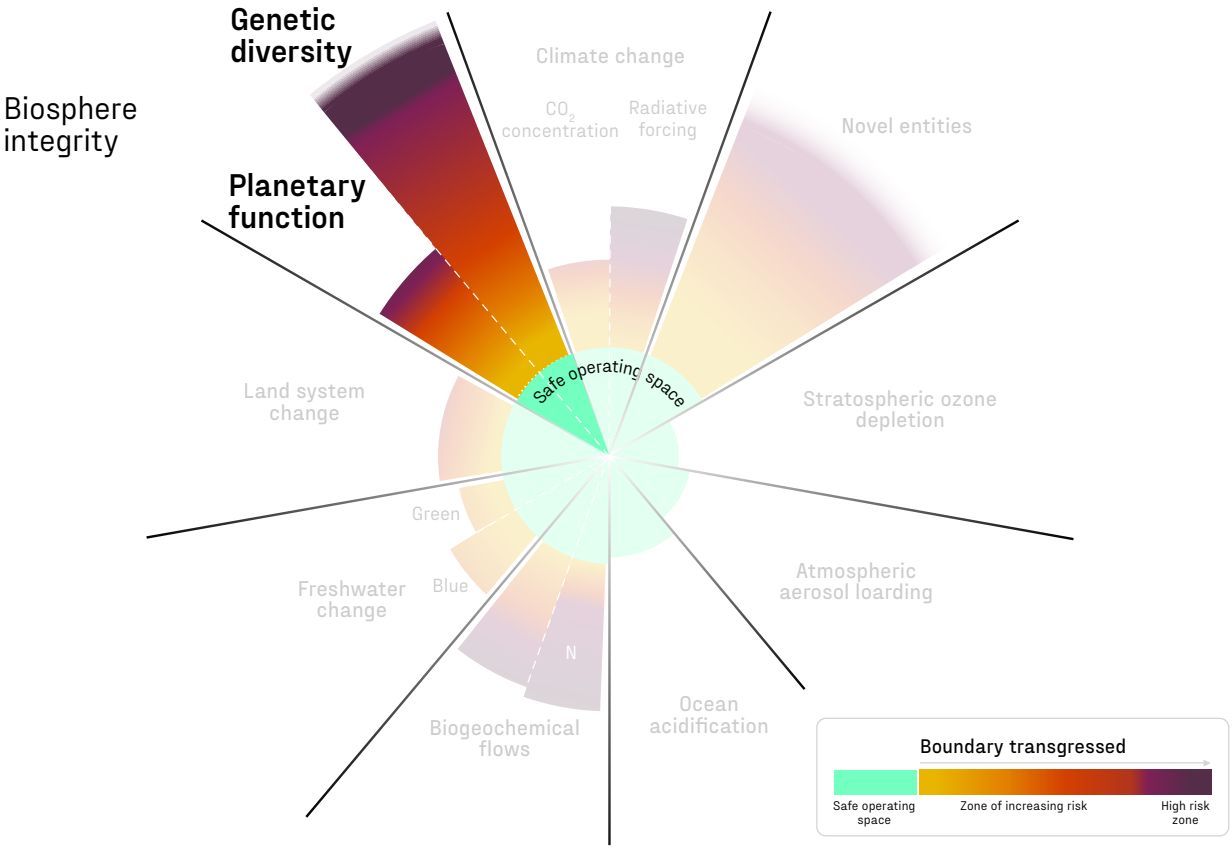
Ecosystem Service	Indicator(s)	50 year trend	Consistency
Habitat creation and maintenance	• Extent of suitable habitat • Biodiversity intactness	↓ ↓	Consistent
Pollination and dispersal of seeds and other propagules	• Pollinator diversity • Extent of natural habitat in agricultural areas	↓ ↓	Consistent
Regulation of air quality	• Retention and prevented emissions of air pollutants by ecosystems	↘	Variable
Regulation of climate	• Prevented emissions and uptake of greenhouse gases by ecosystems	↘	Variable
Regulation of ocean acidification	• Capacity to sequester carbon by marine and terrestrial environments	→	Variable
Regulation of freshwater quantity, location, and timing	• Ecosystem impact on air-surface-ground water partitioning	↘	Variable
Regulation of freshwater and coastal water quality	• Extent of ecosystems that filter or add constituent components to water	↘	Consistent
Formation, protection, and decontamination of soils	• Soil organic carbon	↘	Variable
Regulation of hazards and extreme events	• Ability of ecosystems to absorb and buffer hazards	↘	Variable
Regulation of detrimental organisms and biological processes	• Extent of natural habitat in agricultural areas • Diversity of competent hosts of vector-borne diseases	↓ ↘	Consistent
Energy	• Extent of agricultural land: potential land for bioenergy production • Extent of forested land	↗ ↘	Variable
Food and feed	• Extent of agricultural land: potential land for food and feed production • Abundance of marine fish stocks	↗ ↓	Variable
Materials and assistance	• Extent of agricultural land: potential land for material production • Extent of forested land	↗ ↘	Variable
Medicinal, biochemical, and genetic resources	• Fraction of species locally known and used medicinally • Phylogenetic diversity	↘ ↓	Consistent
Learning and inspiration	• Number of people in close proximity to nature • Diversity of life from which to learn	↓ ↓	Consistent
Physical and psychological experiences	• Area of natural and traditional landscapes and seascapes	↘ ↘	Consistent
Supporting identities	• Stability of land use and land cover	↘	Consistent
Maintenance of options	• Species' survival probability • Phylogenetic diversity	↓ ↓	Consistent

Source: IPBES, 2019

What is the current condition of biodiversity?

The Biosphere is at risk

The Stockholm Resilience Centre[1] identifies biosphere integrity as one of nine biophysical processes that are critical for functioning Earth systems. Six planetary boundaries are currently being pushed beyond their limits by human activity, but none more so than biosphere integrity. Genetic diversity and planetary function are the two dimensions that comprise biosphere integrity, and each is being pushed well into the “high-risk zone”.



Source: Graphic based on Richardson, K., et al. (2023). Earth beyond six of nine planetary boundaries. Science advances, 9(37), eadh2458.

1. The Stockholm Resilience Centre is a world-leading research center at Stockholm University that focuses on addressing complex challenges facing humanity and played a significant role in developing the planetary boundaries framework.

Planetary function

The biomass available to ecosystems is lower due to human appropriation of net primary productivity (HANPP)[1]. Net primary productivity (NPP)[2] is fundamental for supporting ecosystem maintenance, growth, reproduction, differentiation, and networking. In short, land-use change and species exploitation means the energy flows in ecosystems are being severely disrupted.

Boundary: 10% **Status:** 30%

1. HANPP is the difference between the amount of NPP that would be available in an ecosystem in the absence of human activities and the amount of NPP which actually remains in the ecosystem.

2. NPP is the rate of accumulation of biomass or energy per unit of land surface and time.

Genetic diversity

Species are going extinct >10x faster than is required for a functional ecosystem.

Boundary:

<10 extinctions/million species-years (E/MSY). i.e., for every one million species there are on Earth, <10 species will go extinct every year.

Status:

>100 extinctions/million species-years.

What is driving biodiversity loss?

Direct drivers

Land, freshwater, and ocean use

Both the transformation and the intensification of land, freshwater, and sea-use. To date, 75% of ice-free land and 66% of oceans have been severely altered, while 85% of wetlands have been lost.

Direct species exploitation

The extraction or harvesting of wild organisms or other biological products from ecosystems, and extraction or abstraction of water or soil. Global biomass of wild mammals has declined 82% since prehistory.

Invasive species

Purposeful or unintentional introduction of invasive species can disrupt the ecological functioning of natural ecosystems. Nearly 1/5th of Earth's surface is at risk of plant and animal invasions.

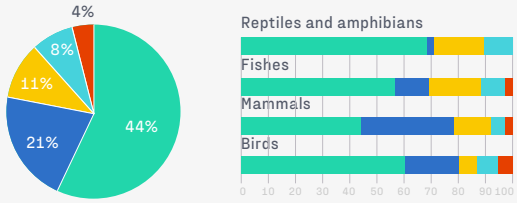
Pollution

The introduction of contaminants into the natural environment that cause adverse change, such as pesticides, excess nutrients, plastic pollution, sulphur and nitrous oxide emissions, and many other contaminants.

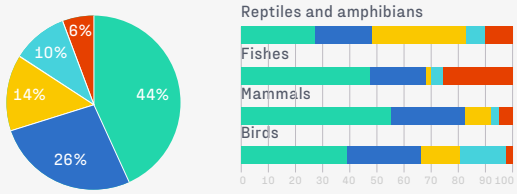
Climate change

Anthropogenic greenhouse gas emissions are increasing global average temperatures, causing sea level rise, and destabilising weather patterns. Global surface temperature was 1.09°C higher in the past decade than 1850-1900 (IPPC, 2021).

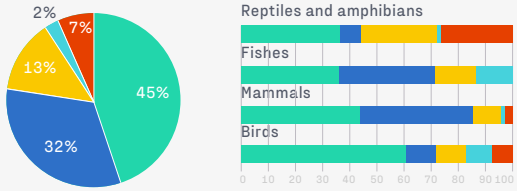
Europe and Central Asia



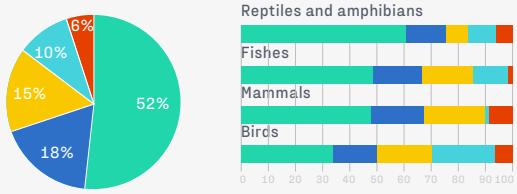
Asia and the Pacific



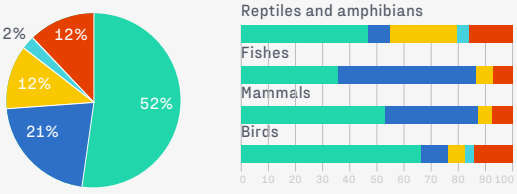
Africa



North America



Latin America and the Caribbean



The colours relate to the key on the left hand side

Source: Graphics based on Figure 4 from Westveer, J, Freeman, R., McRae, L., Marconi, V., Almond, R.E.A, and Grooten, M. (2022) A Deep Dive into the Living Planet Index: A Technical Report. WWF, Gland, Switzerland

Indirect drivers

- Demographics & Sociocultural
- Economic & Technological
- Institutions & Governance
- Conflicts & Epidemics

Source: IPBES, 2019

Biodiversity and climate change are inherently interconnected

Climate change drives biodiversity loss and biodiversity loss also accelerates climate change. The risk of species extinction increases with every degree of warming. Meanwhile, the land and ocean, and the biodiversity they contain, are crucial for climate change mitigation and adaptation through ecosystem services such as providing carbon sinks.

2-3x

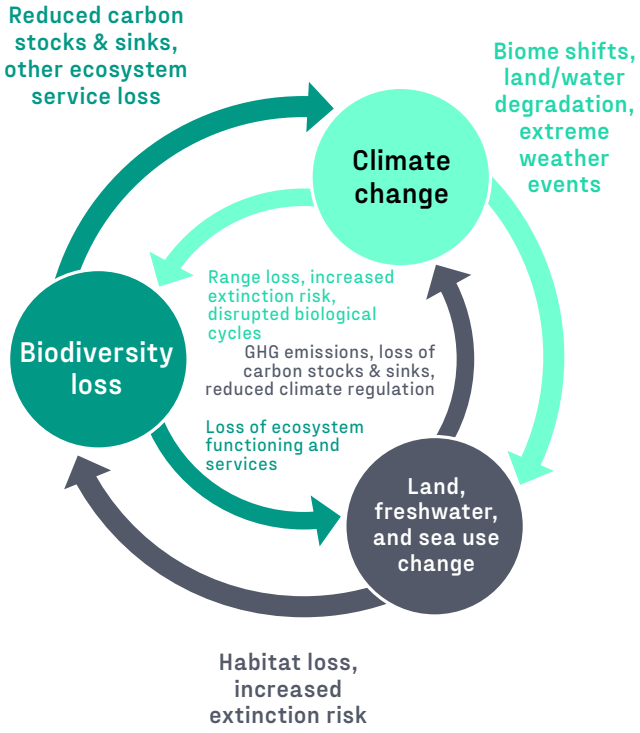
the number of vertebrates, insects, and mammals that lose at least half of their geographic range from 1.5°C to 2.0°C of warming.

IPCC, 2022

23 Gt CO_2/year

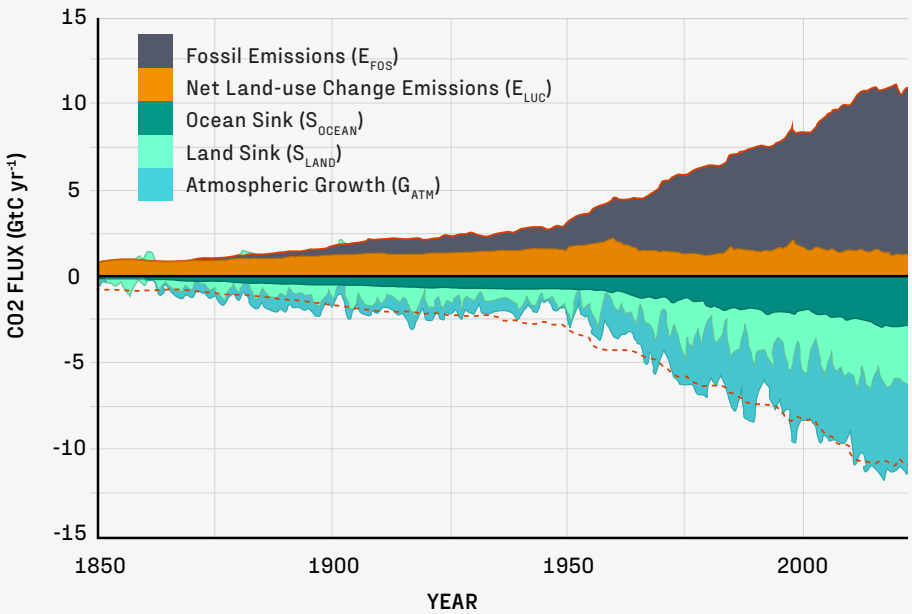
anthropogenic CO_2 emissions sequestered by the land and ocean, and the biodiversity they contain between 2013-2022.

Friedlingstein et al., 2023



Source: Graphic based on Figure 1 from Planetary Security Initiative. (2023, July 10). Climate change & environment nexus brief: Biodiversity and sustainable development.

Sources and Sinks of Carbon



Anthropogenic CO_2 emissions sequestered by the land and ocean, and the biodiversity they contain between 2013-2022.

Ocean sink
2.9 Gt C/year
10.4 Gt CO_2/year
26% anthropogenic CO_2 emissions

Land sink
3.3 Gt C/year
12.3 Gt CO_2/year
31% anthropogenic CO_2 emissions

Atmospheric Growth
5.2 Gt C/year
18.9 Gt CO_2/year
47% anthropogenic CO_2 emissions, contributing to climate change

1 kg carbon (C) =
3.664 kg carbon dioxide (CO_2)

The bottom red line mirrors total emissions, thus representing the imbalance of sources and sinks of CO_2. The budget imbalance for 2023 was 4% or -1.6 Gt CO_2/year, caused by a mismatch in reported sources and sinks of CO_2.

Source: Graphic based on Figure 3a from Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Bakker, D. C., Hauck, J., ... & Zheng, B. (2023). Global carbon budget 2023. Earth System Science Data, 15(12), 5301-5369.

Global Action on Biodiversity

The past few years have been pivotal for global action on biodiversity. Countries around the world agreed to halt and reverse nature loss, while new tools and regulations were released to direct nature-positive business decisions. Below we showcase a handful of recent developments.

Global agreement on Biodiversity

Convention on Biological Diversity

COP15: Kunming-Montreal Global Biodiversity Framework (GBF)

In December 2022, the 15th Conference of the Parties to the Convention on Biological Diversity (COP15) concluded with the adoption of the Kunming-Montreal Global Biodiversity Framework (GBF), a landmark agreement signed by 196 countries which commits them to 23 targets by 2030 and 4 long-term goals by 2050, a "Paris Agreement for Nature".

23 Targets for 2030, including goals to:

- Conserve and restore 30% of land and oceans.
- Halt human induced extinction of known threatened species.
- Reduce invasive species spread and pollution and minimise impacts of climate change.
- Provide $200 billion/year of biodiversity funding.
- Reduce biodiversity harmful subsidies by $500 billion/year.

4 Goals by 2050:

- **Goal A:** Increase the health and area of natural ecosystems, reduce the extinction rate and risk to all species tenfold, and maintain genetic diversity within populations.
- **Goal B:** Sustainably use and manage biodiversity, and restore and preserve ecosystem services.
- **Goal C:** Share the benefits from utilising genetic resources fairly and equitably.
- **Goal D:** Progressively close the $700 billion/year biodiversity funding gap and ensure all countries have adequate means to implement goals.

Accounting for nature risk

European Commission

EU Corporate Sustainability Reporting Directive (CSRD)

Reducing impact on nature — Pending

European Commission

EU Nature Restoration Law

Accounting for nature risk

TNFD

Taskforce on Nature-related Financial Disclosures (TNFD)

Reducing impact on nature

SCIENCE BASED TARGETS NETWORK
GLOBAL COMMONS ALLIANCE

Science-based Targets Network for nature

2024 will be a critical year for companies, financial institutions, and policymakers to progress towards enacting high-level agreements, establishing targets, and initiating action plans to conserve and restore nature.

Closing the Biodiversity Funding Gap

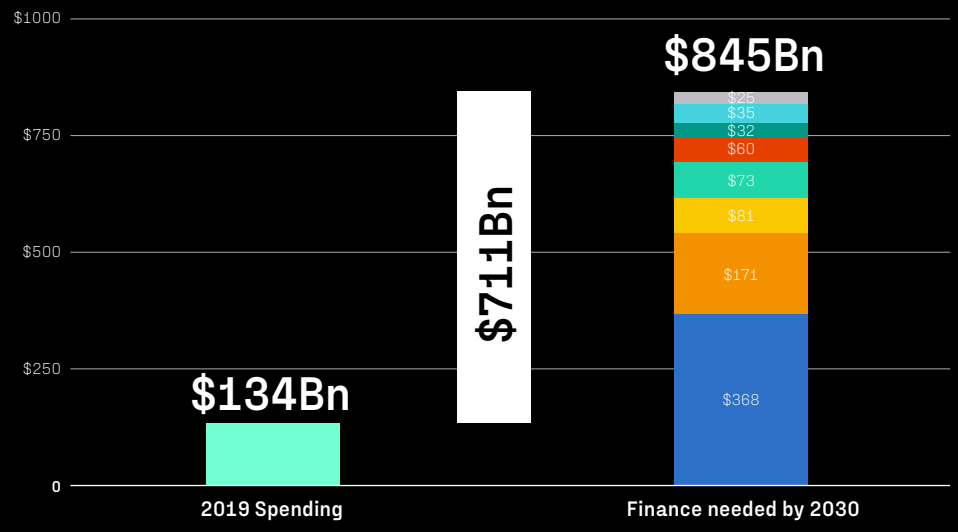
Current biodiversity finance is insufficient to manage biodiversity and maintain ecosystem integrity. Action is needed to close the $600-820 billion annual biodiversity funding gap.

Source: Deutz, et al. 2020. Financing Nature: Closing the global biodiversity financing gap. The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability.

$120-140 billion
biodiversity finance provided in 2019

$720-970 billion
annual biodiversity finance needed by 2030 to halt decline in biodiversity

Source: Deutz, et al. 2020.



Source: Graphic based on data from Figure 1, Figure 3 and Figure 4 from Deutz et al., 2020

Inaction will cost more than immediate action

Our economic and social structures are untenable without nature.

$58 trillion
global GDP that is moderately or highly dependent on nature and its services PwC (2023)

$2.7 trillion
drop in global annual GDP by 2030 compared with baseline scenario under partial ecosystem collapse
The World Bank (2021)

$10.1 trillion

value that could be generated by 15 nature-positive transitions by 2030

World Economic Forum (2020)

What are the key solutions to reverse biodiversity loss?

A portfolio of actions across all sectors is needed to halt and reverse biodiversity loss. The following is a high-level overview of core transitions in human activities that can drive the shift to a nature-positive economy. Transparent, standardised, and high-quality biodiversity data and analysis are key to both informing and evidencing these transitions.

Cities and infrastructure

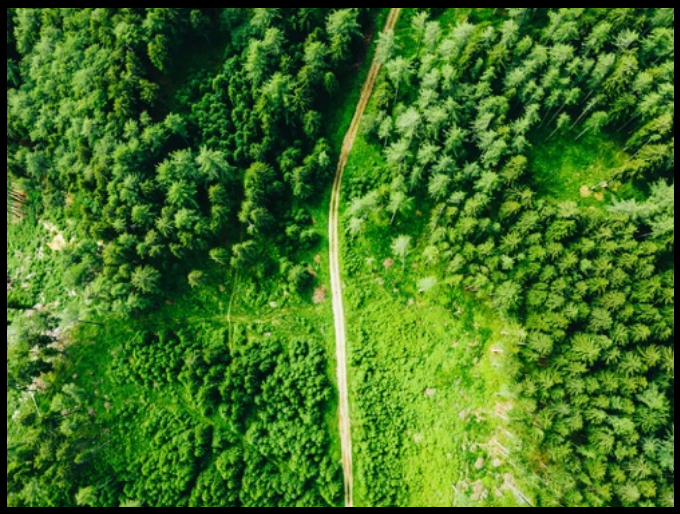
- Consider the impact of cities on ecosystems in distant locations by promoting sustainable material usage in construction, efficient transportation networks, effective waste management, and sustainable food, material, and energy consumption.
- Increase utilisation of green and blue infrastructure, including the preservation and establishment of parks and wetlands.
- Include biodiversity considerations in the planning and development of infrastructure investments, such as transportation and real estate projects.
- Promote urban governance at the local level and transdisciplinary planning that considers biodiversity alongside other societal requirements.

Climate action

- Conserve and restore ecosystems, particularly old-growth forests, seagrass, peatlands, mangroves, wetlands, and other high-carbon-storing ecosystems.
- Reduce emissions from agriculture and forestry, including methane and nitrous oxides and synthetic fertiliser, water, residue, and manure emissions, while promoting soil carbon sequestration.
- Make use of green and blue infrastructure, especially in cities, to support ecosystem-based climate mitigation, adaptation, and disaster risk reduction.
- Promote sustainable renewable energy and energy transition infrastructure, for example, by minimising the negative impacts of mining, enforcing recycling and appropriately siting and designing projects.

Source: The following solutions are based on 8 transitions to a nature-positive economy outlined by Secretariat of the Convention on Biological Diversity (2020) Global Biodiversity Outlook 5. Montreal.

Land and forests



- Conserve biodiversity through protected areas, especially in areas where biodiversity is plentiful, valuable and at risk, and with full involvement of indigenous peoples and local communities (IPLCs).
- Restore and rehabilitate ecosystems including converted and degraded ecosystems to better conserve biodiversity and provide ecosystem services, with full involvement of IPLCs.
- Manage landscapes to balance biodiversity conservation goals, biomass provision, other ecosystem services, and development goals.
- Adopt integrated approaches to land use and land-use change, including supportive policies and regulations, strong community engagement and transparent data and monitoring.

Freshwater

- Combat pollution and improve water quality, including through wastewater treatment and reuse, regulation of polluting industries, improved agricultural practices, and nature-based solutions.
- Prevent and control invasive species in freshwater ecosystems by regulating major introduction pathways and removing existing invasive species.
- Protect and restore critical habitats such as through protected areas, land-use planning, and habitat restoration programs.
- Prevent overexploitation of freshwater species through improved biological assessments, science-based management and reducing bycatch.
- Integrate environmental flows into water management policy, practice, and law.

Oceans and fisheries

- Protect critical habitats such as important biodiversity sites, sensitive marine regions, and ecologically and biologically significant areas.
- Combat pollution, addressing land and sea-based sources of excess nutrients, plastics, and other pollutants.
- Ensure the sustainability of mariculture production, including sustainably managing and rebuilding fisheries.
- Manage the spread of invasive species via marine pathways.
- Include biodiversity considerations in marine and coastal development.

Source: CBD, 2020

Sustainable agriculture

- Enhance management of land and water by avoiding pesticides and excess fertilisers, promoting the efficient use of water and promoting soil biodiversity.
- Integrate systems of crops, trees, livestock, and/or fish production for productivity and ecological benefits and promote integrated pest and disease management.
- Maintain biodiversity in agricultural ecosystems by promoting crop, tree, livestock, and fish diversity, protecting pollinators and enhancing soil biodiversity.
- Take into account the environmental, health and social externalities of agriculture and food systems, promote sustainable agriculture policies, and redirect biodiversity-harmful agricultural subsidies.

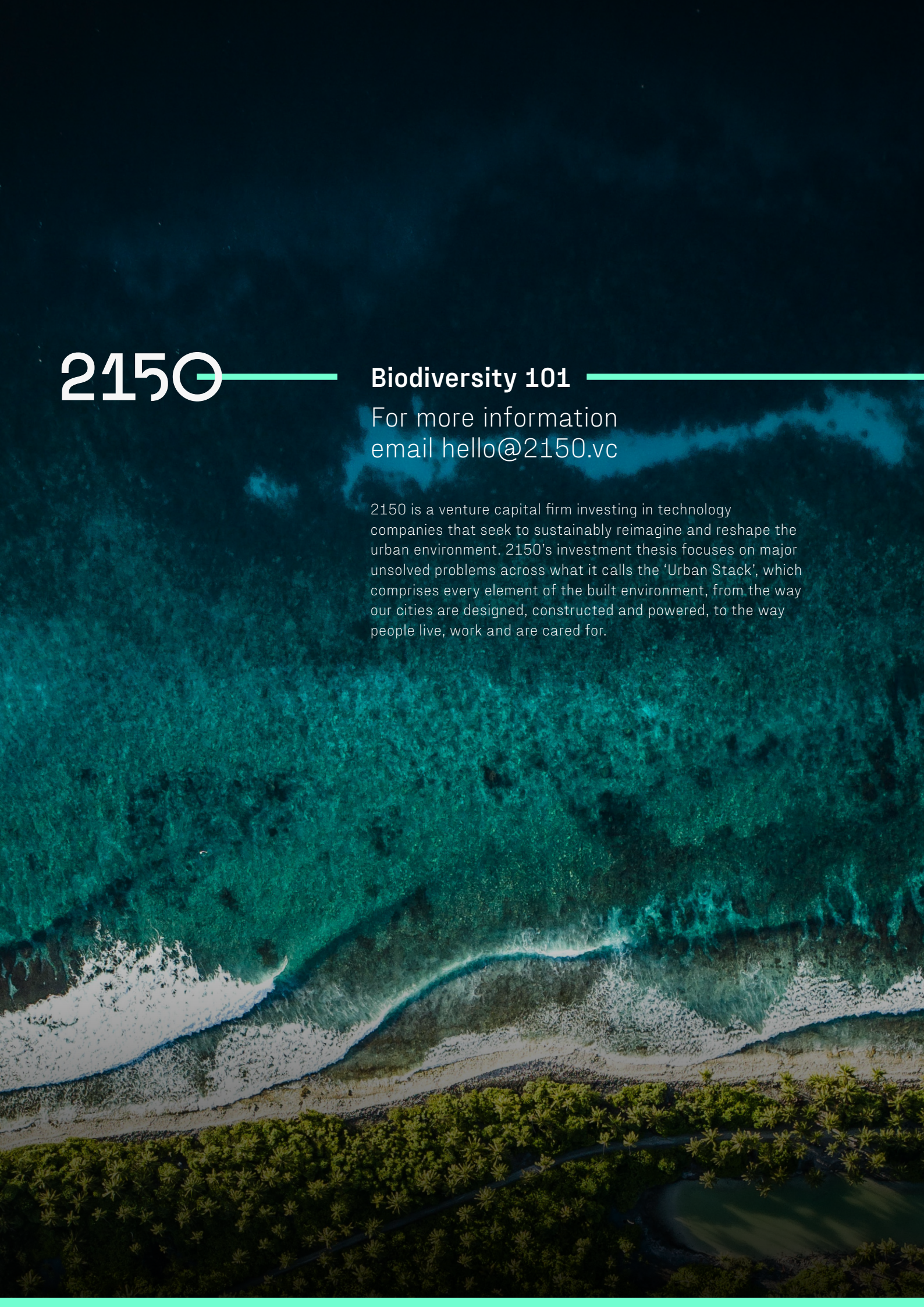
Food systems transition

- Encourage companies to invest in sustainability across supply chains and revamp product offerings with a focus on human and planetary well-being.
- Promote measures to reduce food waste, including through technologies related to harvesting, storing, and transportation of food, or recovering food waste.
- Promote the availability, access, and consumption of healthy and sustainable diets through economic incentives, education, and supportive policies.
- Rebalance agricultural policies and incentives to enhance efficiencies, reduce food loss, and promote nutrition.

Health

- Create healthy cities and landscapes which meet conservation goals, provide ecosystem services, and provide equitable access to green and blue spaces.
- Promote healthy diets that are safe, nutritious, and efficient as a component of sustainable consumption.
- Promote sustainable, legal, and safe agriculture (including crop and livestock production and aquaculture) and use or trade of wildlife.
- Reduce disease risk by conserving and restoring ecosystems, including reducing and reversing land, freshwater, and sea-use change.

Source: CBD, 2020



2150

Biodiversity 101

For more information
email hello@2150.vc

2150 is a venture capital firm investing in technology companies that seek to sustainably reimagine and reshape the urban environment. 2150's investment thesis focuses on major unsolved problems across what it calls the 'Urban Stack', which comprises every element of the built environment, from the way our cities are designed, constructed and powered, to the way people live, work and are cared for.