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THE POST-2020 GLOBAL
BIODIVERSITY FRAMEWORK
Fourth meeting
Nairobi, 21-26 June 2022
Item 4 of the provisional agenda[*]

SCIENCE BRIEFS ON TARGETS, GOALS AND MONITORING IN SUPPORT OF THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK NEGOTIATIONS

Note by the Executive Secretary

1. The Executive Secretary is pleased to circulate herewith, for the information of participants in the fourth meeting of the Open-ended Working Group on the Post-2020 Global Biodiversity Framework, an information document providing scientific information on the proposed targets and goals of the post-2020 global biodiversity framework and associated monitoring issues. The document has been prepared by the bioDISCOVERY programme of Future Earth and the Secretariat of the Group on Earth Observations Biodiversity Observation Network (GEO BON). This document has been revised from an earlier version to include information related to proposed target 8 addressing climate change. It is provided in the form and language it was received by the Secretariat.

2. The document complements other documents made available on this issue for previous meetings including documents CBD/WG2020/3/INF/11, and CBD/SBSTTA/24/INF/9. This note is also relevant to the workshop on options to enhance the planning, monitoring, reporting and review mechanism being held in Nairobi, from 17 to 18 June 2022 and the technical meeting on indicators for the post-2020 global biodiversity framework being held in Bonn, from 29 June to 1 July 2022.

[*] CBD/WG2020/4/1.

SCIENCE BRIEFS ON TARGETS, GOALS AND MONITORING IN SUPPORT OF THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK NEGOTIATIONS

Objectives

Parties have expressed interest in receiving expert input to support the preparation of the post-2020 global biodiversity framework (GBF) during the meeting of the Subsidiary Body on Scientific, Technical and Technological Advice under the Convention on Biological Diversity and meetings of the Open-Ended Working Group (WG2020). The most common issues where additional expert input is seen as useful include:

- justification for wording and quantitative elements of goals and targets,
- definitions for key terminology
- assessment of the adequacy and availability of indicators and the monitoring framework for tracking achievement of goals and targets, and
- clarification of the relationship between the targets, which focus on actions to alter drivers, and the goals which focus on outcomes for biodiversity and nature's contributions to people (NCP).

The Secretariat of the Convention, the Co-Chairs of the Working Group on the Post-2020 Global Biodiversity Framework and a variety of organizations have already compiled a substantial amount of information to address these issues (see for example CBD/SBSTTA/24/3/Add.2 and CBD/WG2020/3/INF/3), but further expert input on specific issues additional in-depth and up-to-date analyses would be useful.

To address these issues, the bioDISCOVERY programme of Future Earth and the Secretariat of the Group on Earth Observations Biodiversity Observation Network (GEO BON), convened a group of experts to prepare seven briefs to provide support for the negotiations of the GBF at the fourth meeting of the Working Group on the Post-2020 Global Biodiversity Framework in Nairobi, from 21 to 26 June 2022. This includes five briefs on individual targets, a brief on the GBF monitoring framework, and a brief on the ecosystem area and integrity objectives of the GBF (see below for details).

Experts from the international scientific community were primarily drawn from the pool of experts who prepared two previous information documents (see paragraph below) that were convened by bioDISCOVERY programme of Future Earth, the Secretariat of GEO BON and/or the Earth Commission of Future Earth:

1. *Expert Input To The Post-2020 Global Biodiversity Framework: Transformative Actions On All Drivers Of Biodiversity Loss Are Urgently Required To Achieve The Global Goals By 2050* (CBD/WG2020/3/INF/11; provided in support of the WG2020-3 in March 2022, and see summary in Leadley et al. 2022[1]).
2. *Synthesizing The Scientific Evidence To Inform The Development Of The Post-2020 Global Framework On Biodiversity* (CBD/SBSTTA/24/INF/9, see also Diaz et al. 2020[2]).

Respectively, these focused on the structure and coherence of goals and targets in the first draft of GBF, and on wording and quantitative elements of the goals related to biodiversity and nature's contributions to people in the zero draft of the GBF.

List and structure of the science briefs

In contrast with the two previous contributions from Future Earth and GEO BON mentioned above, these new science briefs focus on the specific wording and numerical objectives of five targets or two specific parts of the GBF.

This focus on only five targets was based on the expertise available in the pool of experts (see above) that could be mobilized, and was also constrained by the short time between the third and the fourth meetings of the Working Group on the Post-2020 Global Biodiversity Framework. The selection of

[1] Leadley et al. (2022). *EcoEvoRxiv*, https://ecoevorxiv.org/hy7a2/ and *One Earth* (in press)

[2] Díaz et al. (2020) *Science* 370: 411–13. https://doi.org/10.1126/science.abe1530.

targets is not intended to reflect the relative importance of the targets, all of which have been shown to be critical to the goals of the GBF (CBD/WG2020/3/INF/11).

This version of this information document includes a brief on Target 7 (Pollution) and Target 8 (Climate change). The remaining three briefs will be provided in a revised version of this information document prior to the fourth meeting of the Working Group on the Post-2020 Global Biodiversity Framework.

A collection of the key messages from all the briefs can be found starting on page 1 below.

<u>Target briefs</u>

Targets analysed:

Target 3 – Protected areas and OECMs

Target 7– Pollution (note: this brief focuses on nitrogen and phosphorus pollution component of this target) – Starts on page 4 of the present document.

Target 8– Climate change impacts, adaptation and mitigation – Starts on page 24 of the present document.

Target 10 – Sustainable agriculture, aquaculture and forestry (note: this brief focuses on the sustainable agriculture component of this target)

Structure of the target briefs:

- Key messages – 1 page summary of the main points of the brief
- Background – Short, well-referenced syntheses of the evidence supporting the key messages
  - Relevance for biodiversity, nature's contributions to people and good quality of life
  - Target formulation, numerical objectives, indicators and impacts on SDGs
  - Indicators
  - Linkages to other relevant international policies
  - References
- Appendix – Graphics, tables and short texts in support of the background material

<u>Ecosystem area and integrity brief</u>

This brief focuses on the relationships between the ecosystem objectives of Goal A and the targets that directly contribute to meeting these objectives. The structure of this brief is as follows :

- Key messages – 2 page summary of the main points of the brief
- Ecosystem Area and Integrity: Quantitative and Qualitative Relationships between Goal A and Targets
- Appendix – Graphics, tables and short texts in support of the background material

Notes: The absence of an analysis of connectivity in this brief does not indicate that the connectivity components of Goal A and the targets are not important: it only reflects limitations of time and expertise mobilized for this brief. This brief will accompanied by a glossary with suggestions for annotations and additions to the GBF glossary.

SCIENCE BRIEFS IN SUPPORT OF THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK

KEY MESSAGES

The collection of key messages that follows is intended to provide an overview of the in-depth analyses in the full-length science briefs. The key messages also appear at the beginning of each of the full briefs.

Target 7–pollution (page 2)

Authors: David Kanter, Niklas Möhring, Paul Leadley, Tariq Aziz, Italo Castro, Federico Maggi, Ralf Schulz, Lena Schulte-Uebbing, Fiona Tang, Xin Zhang.

Target 8–climate change (page 3)

Authors: Emma Archer, Paul Leadley, David Obura, Almut Arneth, Mark John Costello, Simon Ferrier, Akira S. Mori, Carlo Rondinini, Pete Smith.

Target 3–protected areas and OECMs, Target 10–sustainable production systems, and ecosystem area and integrity

This additional collection of three briefs will be provided prior to the fourth meeting of the Working Group on the Post-2020 Global Biodiversity Framework to be held in Nairobi, from 21 to 26 June 2022.

KEY MESSAGES CONCERNING THE NUTRIENT AND PESTICIDE POLLUTION OBJECTIVES OF TARGET 7

- Nutrient (nitrogen and phosphorus) and pesticide pollution are widespread and have well-documented negative impacts on nature, nature's contributions to people, agricultural sustainability and human health.
- Agriculture is the primary source of nutrient and pesticide pollution. Large reductions in nutrient and pesticide pollution from agriculture by 2030 would have significant benefits for nature and people, and can be achieved without compromising food security or livelihoods.
- The level of ambition for reductions in nutrient and pesticide pollution should seek a middle ground between the very deep cuts needed to achieve low risk for nature and what is feasible by 2030 without compromising food security.
- Reductions in fertilizer and pesticide use, in cases where they lead to reduced agricultural productivity, could lead to loss of natural habitats through land use change, a major driver of biodiversity loss. Systemic approaches to food production, distribution and consumption could avoid this.
- Looking towards 2050, transformative changes in food systems and other sources of nutrient and pesticide pollution should be initiated now because these provide opportunities for deep, long-term reductions in pollution, and provide many other benefits for nature and people.
- Measures to reduce pollution should be adapted to national contexts because sources, levels and impacts of pollution; effects on food production; and feasibility of reductions vary greatly.

Nutrients

- Based on the best available scientific evidence, the Target 7 objectives for nutrients are technically feasible and coherent with other international policies.
- Agriculture is the dominant source of nutrient pollution globally and in most countries; other important sources include wastewater, industry and biomass burning.
- Nutrient <u>losses</u> from agriculture can be reduced by up to 50% at local, national and global scales by 2030 without compromising food security, using existing farm-level practices and technologies as well as through landscape management.
- Available cost-effective mitigation technologies can reduce nutrient pollution from non-agricultural sources such as wastewater and fossil fuel combustion by far more than 50%.
- The current set of indicators for monitoring nutrient pollution under the GBF is not well adapted to assessing achievement of this objective, and should be complemented by other currently available indicators such as nutrient surplus.

Pesticides

- It is important to frame pesticide policies in terms of risk instead of quantity, because very toxic pesticides can pose high risks to certain groups of species even if they are used in low quantities. This could be reflected in the wording of Target 7 by replacing "...pesticides by at least two thirds" with "...risks associated with pesticide use by at least X%".
- Reductions of 20-50% in <u>pesticide risk</u> are achievable now without compromising food security by increasing efficiency and through substitution. Systemic changes and innovation in agriculture and food systems would allow considerably larger reductions.
- The headline indicator of total pesticide use per hectare, should be replaced with environmental risk-based indicators. Risk-based indicators can be calculated using currently available data—more precise risk-based indicators will require efforts to collect better data on pesticide use, exposure per active ingredient and toxicity.

KEY MESSAGES CONCERNING THE CLIMATE CHANGE OBJECTIVES OF TARGET 8

Minimize the impact of climate change on biodiversity

- Keeping climate change to the Paris Agreement objectives of "well below 2°C, and as close as possible to 1.5°C" is essential to achieving the GBF objectives. Even at these levels, climate change will increase extinction risk, cause large shifts in species distributions, alter ecosystem functioning, and compromise nature's contributions to people.
- Improving the resilience of species and ecosystems in the face of climate change is essential. This can be achieved by reducing additional and interacting pressures on biodiversity from land and sea use change, overexploitation, invasive alien species and pollution.
- Spatial planning to protect large areas of intact ecosystems and increase connectivity in multifunctional land and sea-scapes is crucial for climate change adaptation because it will facilitate species range shifts in response to climate change.

Mitigation and adaptation through "ecosystem-based approaches" / "nature-based solutions"

- The conservation and restoration of nature can significantly contribute to climate mitigation. For example, the protection of intact ecosystems and restoration of degraded ecosystems are among the most rapid and cost-effective means of climate mitigation, and can provide a range of other benefits.
- Protecting and restoring natural ecosystems helps species, ecosystems and people to adapt to climate change. For example, protecting and restoring coastal wetlands, mangroves and coral reefs enhances the capacity of socio-ecosystems to adapt to rising sea levels.
- Increasing the integrity of ecosystems used for agriculture, forestry and fisheries, in particular through management practices that reinforce biodiversity, can greatly improve the capacity of these ecosystems and people to adapt to climate change.
- Clear definitions and bounds on ecosystem-based approaches / nature-based solutions for climate are needed to avoid perverse effects on nature and people, and focus should be on measures that provide "wins" for climate, biodiversity and human well-being. Involvement of local actors is essential, taking into account all forms of relevant information, including scientific, cultural and local knowledge, innovations and practices.
- Failure to greatly reduce emissions from all sectors including energy, transport and agriculture will increase climate risks for natural systems and compromise their contributions to mitigation.

Quantitative objective for climate mitigation

- A combination of nature-based solutions / ecosystem-based approaches to mitigation can potentially provide between 5 and 10 $GtCO_2e$ per year mitigation cost-effectively, without compromising production of food and fibre, and with strong safeguards for biodiversity. Achieving these levels of mitigation requires substantial reductions in loss and degradation of natural ecosystems, and large increases in restoration compared to the period 2010-2020. It is essential to note that respecting these safeguards and achieving the high-end estimate of 10 $GtCO_2e$ per year requires ambitious and deep systemic changes in production and consumption, and is broadly consistent with a 5% net gain in natural ecosystems by 2030.
- Setting an ecosystem-based mitigation target in the GBF would be an important complement to goals in the UNFCCC, because it more explicitly stipulates safeguards for biodiversity.

Avoiding negative impacts of mitigation and adaptation efforts on biodiversity

- Competition for land, in particular arising from climate mitigation based on large-scale afforestation and bioenergy production, could be particularly detrimental for biodiversity. Adverse impacts on biodiversity arising from technological measures for adaptation such as construction of dams, seawalls and new irrigation capacity for agriculture should also be avoided.
- Mitigation and adaptation interventions must be well designed and implemented in order to avoid adverse impacts on nature and people, emphasizing equity and social justice.

SCIENCE BRIEFS IN SUPPORT OF THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK

TARGET 7 - POLLUTION

Background on the science briefs

The bioDISCOVERY programme of Future Earth and the Secretariat of the Group on Earth Observations Biodiversity Observation Network (GEO BON), convened a group of experts to prepare seven briefs to provide scientific support for the negotiations of the post-2020 global biodiversity framework (GBF) at the fourth meeting of the Working Group on the Post-2020 Global Biodiversity Framework in Nairobi, from 21 to 26 June 2022. This includes five briefs on individual targets 1, 3, 7, 8 and 10; a brief on the GBF monitoring framework; and a brief on the ecosystem area and integrity objectives of the GBF.

This science brief addresses reducing nutrient and pesticide pollution components of Target 7

The analysis in this brief focuses on the wording and quantitative elements of target 7, definitions of key terminology, and assessment of the adequacy and availability of indicators for tracking achievement this target.

This analysis is based on the text of the first draft of the post-2020 global biodiversity framework, CBD/WG2020/3/3 and subsequent negotiations of this text:

> *Target 7. Reduce pollution from all sources to levels that are not harmful to biodiversity and ecosystem functions and human health, including by reducing nutrients lost to the environment by at least half, and pesticides by at least two thirds and eliminating the discharge of plastic waste.*

This analysis focuses on the nutrient and pesticide pollution. It also briefly summarizes the importance of treating plastic pollution in this target. This does not mean that other sources of pollution, including plastics are not important for the GBF.

Structure of this brief

- Key messages (1 page summary)
- Background
    1) Relevance for biodiversity, nature's contributions to people and good quality of life
    2) Target formulation, numerical objectives, indicators and impacts on SDGs
    3) Indicators
    4) Linkages to other relevant international policies
    5) References
- Appendix – Graphics, tables and short texts in support of the background material

Authors

David Kanter, Niklas Möhring, Paul Leadley, Tariq Aziz, Italo Castro, Federico Maggi, Ralf Schulz, Lena Schulte-Uebbing, Fiona Tang, Xin Zhang.

KEY MESSAGES CONCERNING THE NUTRIENT AND PESTICIDE POLLUTION OBJECTIVES OF TARGET 7

- Nutrient (nitrogen and phosphorus) and pesticide pollution are widespread and have well-documented negative impacts on nature, nature's contributions to people, agricultural sustainability and human health.
- Agriculture is the primary source of nutrient and pesticide pollution. Large reductions in nutrient and pesticide pollution from agriculture by 2030 would have significant benefits for nature and people, and can be achieved without compromising food security or livelihoods.
- The level of ambition for reductions in nutrient and pesticide pollution should seek a middle ground between the very deep cuts needed to achieve low risk for nature and what is feasible by 2030 without compromising food security.
- Reductions in fertilizer and pesticide use, in cases where they lead to reduced agricultural productivity, could lead to loss of natural habitats through land use change, a major driver of biodiversity loss. Systemic approaches to food production, distribution and consumption could avoid this.
- Looking towards 2050, transformative changes in food systems and other sources of nutrient and pesticide pollution should be initiated now because these provide opportunities for deep, long-term reductions in pollution, and provide many other benefits for nature and people.
- Measures to reduce pollution should be adapted to national contexts because sources, levels and impacts of pollution; effects on food production; and feasibility of reductions vary greatly.

Nutrients

- Based on the best available scientific evidence, the Target 7 objectives for nutrients are technically feasible and coherent with other international policies.
- Agriculture is the dominant source of nutrient pollution globally and in most countries; other important sources include wastewater, industry and biomass burning.
- Nutrient <u>losses</u> from agriculture can be reduced by up to 50% at local, national and global scales by 2030 without compromising food security, using existing farm-level practices and technologies as well as through landscape management.
- Available cost-effective mitigation technologies can reduce nutrient pollution from non-agricultural sources such as wastewater and fossil fuel combustion by far more than 50%.
- The current set of indicators for monitoring nutrient pollution under the GBF is not well adapted to assessing achievement of this objective, and should be complemented by other currently available indicators such as nutrient surplus.

Pesticides

- It is important to frame pesticide policies in terms of risk instead of quantity, because very toxic pesticides can pose high risks to certain groups of species even if they are used in low quantities. This could be reflected in the wording of Target 7 by replacing "...pesticides by at least two thirds" with "...risks associated with pesticide use by at least X%".
- Reductions of 20-50% in <u>pesticide risk</u> are achievable now without compromising food security by increasing efficiency and through substitution. Systemic changes and innovation in agriculture and food systems would allow considerably larger reductions.
- The headline indicator of total pesticide use per hectare, should be replaced with environmental risk-based indicators. Risk-based indicators can be calculated using currently available data—more precise risk-based indicators will require efforts to collect better data on pesticide use, exposure per active ingredient and toxicity.

BACKGROUND ON THE NUTRIENT AND PESTICIDE POLLUTION OBJECTIVES OF TARGET 7

1) Relevance for biodiversity, nature's contributions to people and good quality of life

The IPBES Global Assessment (IPBES 2019) ranked pollution as one of the five main drivers of biodiversity loss, accounting for about 12%, 17% and 15% of biodiversity loss in terrestrial, freshwater and marine ecosystems. Pollutants of concern affecting biodiversity and nature's contributions to people include nutrients, pesticides, plastics, industrial chemicals, heavy metals, light and noise. We provide background below on why nutrient (nitrogen and phosphorus) and pesticide pollution are of particular concern and are the focus of this brief. Because agriculture is the most important source of nitrogen, phosphorus and pesticide pollution, it is also the most important leverage point for reducing these forms of pollution.

Nutrient pollution refers to nitrogen (N) and phosphorus (P) pollution, which is one of the "planetary boundaries" most seriously transgressed (Steffen et al. 2015). It has been the focus of numerous global, regional and national policy targets (see section 4), including Aichi Target 8. Excessive nutrient losses to the environment can lead to detrimental impacts on biodiversity through a wide range of mechanisms (Lu and Tian 2017, Wang et al. 2016, Beasley 2020, Hernández et al. 2016, Sutton et al., 2021, Appendix-Table 1). Nutrient pollution in water causes eutrophication and dead zones—extremely low-oxygen environments which kill most aquatic life (Breitburg et al. 2018). Controlling this nutrient pollution can successfully reduce the eutrophication (Schindler et al. 2016). Emissions of reactive nitrogen gases, such as nitrogen oxides from car exhaust and ammonia from synthetic fertilizer and manure application, cause atmospheric N deposition onto natural terrestrial ecosystems that disrupts ecological balances and threatens biodiversity (Stevens et al. 2010). Nitrogen's substantial contributions to air pollution (e.g., NO_x directly and as a precursor of tropospheric ozone pollution), acid rain, greenhouse gas emissions (N_2O is the third most important greenhouse gas behind CO_2 and methane) and stratospheric ozone depletion also lead to well-documented contributions to climate change as well as damage to biodiversity, agricultural productivity and human health (Stevens et al. 2020, de Vries 2021, Appendix-Table 1). Critical thresholds for nitrogen and phosphorus have been established for many terrestrial and aquatic ecosystems and are highly context dependent (Bobbink et al. 2010, de Vries et al. 2015, Poikane et al. 2019, Appendix-Table 1). These critical thresholds are greatly exceeded in large areas of the globe (Bleeker et al. 2011, Chang et al. 2021, De Vries et al. 2021). In addition, significant impacts on biodiversity occur in some ecosystems even below current critical thresholds (Stevens et al. 2010). The take-home message is that **reducing nutrient pollution is a key to preserving and restoring biodiversity, achieving ambitious climate targets and protecting human health.**

Pesticide pollution in Target 7 primarily refers to pollution by plant protection products used for crop production since agriculture contributes to more than 80% of total pesticide used (Maggi et al. 2019). Agricultural use of pesticides has been shown to pose higher risks than urban use (Stehle et al. 2019). Pesticide use in other settings such as aquaculture and livestock production has not been well quantified. Globally, about two thirds of agricultural land is at risk of pesticide pollution by more than one active ingredient, and about a third is at high risk (Tang et al. 2021, see Appendix-Figure 1). Pesticide pollution threatens global terrestrial, freshwater and marine biodiversity (Geiger et al. 2010, Stehle & Schulz 2015, IPBES 2016, Sánchez-Bayoa and Wyckhuys 2019, Li et al. 2020), and their use expressed in terms of total applied toxicity is increasing for invertebrates and plants (Schulz et al. 2021). Pesticides also reduce ecosystem services that are essential for agricultural production such as pollination, natural pest control, beneficial soil organisms, and nutrient cycling (Köhler & Triebskorn 2013, Chagnon et al. 2015, Onwona-Kwakye 2020), and may threaten agricultural productivity over the long term rather than ensuring it (Mader et al. 2002). Pesticides also have important adverse effects on human health (Landrigan et al. 2018, Maggi et al. 2021, Appendix-Figure 4). The take-home message is that **reducing pesticide pollution is a key to preserving and restoring biodiversity, and also has substantial benefits for agricultural productivity, nature's contributions to people and human health.**

The focus on nutrients and pesticides in this brief does not mean that other sources of pollution are not important for the GBF. Plastic pollution is of particular concern because globally more than 25 million tonnes of plastics were emitted to aquatic and terrestrial environments every year (Lau et al.

2020, MacLeod et al. 2021). A recent analysis shows that more than 900 marine megafaunal species (including seabirds, marine mammals, sea turtles, fishes) were affected by entanglement and/or ingestion of plastics (Kühn & Van Franeker 2020). Ingestion of microplastics by animals and humans can cause physical injury, changes in physiology, and impaired feeding, growth and reproduction rates (Prinz & Korez 2020). These concerns recently led the UN Environment Assembly to establish a process to set international goals for halting plastic pollution. The current draft of the GBF monitoring framework recognizes the multiple forms of pollution that are important to mitigation and includes indicators for plastics, municipal solid waste, underwater noise pollution and hazardous waste generation, which could be supplemented with additional indicators. A 2021 policy brief from UNEP and the Basel, Rotterdam, Stockholm Conventions (BRS), and the Minamata Convention on Mercury (MC), concerning the relationships between biodiversity and chemical pollution can be found at this link (Interlinkages between the chemicals and waste multilateral environmental agreements and biodiversity: Key insights).

2) **Target formulation, numerical objectives, indicators and impacts on SDGs**

Target 7 was analyzed in this brief by breaking it down into its individual components. This is similar to the approach used for the Aichi Target analyses in the fourth and fifth editions of the *Global Biodiversity Outlooks*, as well as the “one-pager” summaries of the GBF goals, milestones and targets (CBD/WG2020/3/INF/3). Note that we did not address the plastic pollution component of this target.

➢ ***"Reduce pollution from all sources to levels that are not harmful to biodiversity and ecosystem functions and human health"***

This first component of Target 7 addresses all a wide range of pollutants and should logically be pursued as essential for protecting biodiversity and as a follow-up to Aichi Target 8. However, this target covers a very wide spectrum of pollutants, making progress difficult to evaluate. In addition, levels that are “not harmful to biodiversity and ecosystem functions and human health” are not well defined for most pollutants and are context-dependent (see Appendix-Tables 1&2). As such this component of Target 7 provides a broad statement of high ambition, but progress towards attaining the objective will be more difficult to assess than for individual classes of pollutants.

➢ ***"including by reducing nutrients lost to the environment by at least half"***

Anthropogenic nitrogen and phosphorus losses have several sources, but the major source is agriculture (Appendix-Figure 2). Nutrients are one of the main agricultural inputs for the production of food, feed, fiber, and biofuels, but oversupply of synthetic fertilizers and manure to agricultural land contributes over 60% of global N and P losses to the environment (MacDonald et al. 2016, Chowdhury et al. 2017, Withers et al. 2018, Kanter & Brownlie 2019, see Appendix-Figure 2). Human waste and food waste are other important sources of N and P pollution (approximately 10%-20%). Significant sources that are unique to N include industry (notably NO_x and N_2O emissions from nitric and adipic acid production), fossil fuel combustion (for both energy production and transport) and biomass burning. Together these sources are responsible for approximately 25% of anthropogenic N losses to the environment.

Target formulation **-** Given the multiple sources of pollution an important question is whether to focus exclusively on agriculture or include all sources of nutrient pollution. A focus on agriculture would enable a narrowly defined spotlight on the dominant source of nutrient pollution, with a limited set of indicators (fertilizer use, nutrient use efficiency, nutrient surplus…) creating a simpler approach to measuring progress towards Target 7. **A broad approach to nutrient pollution mitigation is more scientifically and economically sound than strictly focusing on agriculture**. First, excluding non-agricultural sources would omit significant and growing sources of nutrient pollution, limiting the potential benefits for biodiversity of achieving Target 7. Second, several of the measures to address non-agricultural sources, such as pollution from wastewater, are considerably cheaper and/or easier to implement because they rely on using market-ready technologies and can reduce emissions considerably more than most agricultural measures (Winiwarter et al. 2018). Finally, agriculture’s contribution to nutrient pollution relative to other sectors varies significantly across countries, and therefore limiting Target 7’s focus to agriculture would mean that countries with significant non-agricultural sources would not experience as much of a benefit to biodiversity from such a narrow focus (Sutton et al. 2013).

Numerical objectives, indicators and relationship to SDGs **- Halving nutrient losses to the environment by 2030 can be justified from environmental, agronomic and technical perspectives.** From an environmental standpoint, halving nutrient losses is in line with the planetary boundaries literature, which suggests that humanity needs to halve the amount of N and P introduced into the Earth System to return to a safe operating space (Steffen et al. 2015, De Vries et al. 2013). From an agronomic standpoint, Zhang et al. (2015) have estimated that to meet the 2050 food demand and bring N pollution back to the planetary boundary, total annual N surplus from the world's croplands needs to be reduced by about 50% (from 100 million tonnes N per year to 52 million tonnes N per year). Such reduction could be achieved by ambitious yet realistic and regionally tailored increases in N use efficiency (NUE, the proportion of N applied that is harvested vs. lost to the environment).

The possibility to significantly reduce nutrient losses without compromising agricultural productivity is supported by field experiments across multiple agricultural systems. For example, a recent study in China showed that a combination of improved management practices, enhanced efficiency fertilizers, mechanization and manure management could increase wheat, maize and rice yields by approximately 10% and NUE by almost 30% while reducing cropland nitrous oxide emissions and nitrate leaching by 50% and 40%, respectively, as well as livestock N losses by 20% and greenhouse gas emissions due to N fertilizer production, transport and application by over 15% compared to a 2012 baseline scenario (Guo et al. 2020). A global study that assessed the mitigation potential of improved management, reductions in food loss and waste and shifts towards more plant-based diets showed a decrease in N and P application by a half and two thirds, respectively, in 2050 relative to a baseline scenario that does not include any specific mitigation measures and a middle-of-the-road development pathway (Springmann et al. 2018). About 50% or even more reduction in N and P losses have been reported by fertilizer management strategies like band placement, deep placement, use of controlled release fertilizers (Yao et al. 2018, Zeng et al. 2008, Irfan et al. 2018, Wang and Huang 2021).

For non-agricultural sectors, several technologies are available to reduce industrial emissions by over 90% and transport emissions by over 50% and possibly more for the latter with a significant transition towards electric vehicles powered by low carbon electricity sources (Kanter et al. 2017). For wastewater, technologies exist to recover 75% of N and 20%-50% of P for reuse in agriculture, while wastewater treatment technologies can reduce the concentration of N and P in wastewater by up to 80% and 96%, respectively (Kanter & Brownlie, 2019).

One critical issue is the choice of baseline, i.e. halving nutrient losses to the environment compared to what? While some studies compare mitigation efforts to a counterfactual "no-action" trajectory, these trajectories are based on a variety of assumptions on economic and population growth, technological innovation and education levels amongst other variables that may not come to pass (Kanter et al. 2020). Consequently, baselines based on past years of recorded nutrient losses (possibly even an average across several years to account for interannual variability) is a much more scientifically defensible and measurable approach, using data on nutrient use efficiency and nutrient surpluses from sources such as Zhang et al. (2015) and Zhang et al. (2021a).

Adapting objectives to national contexts **- The goal of halving nutrient losses to the environment is a feasible global objective, but its implementation should be adapted to national circumstances.** Some countries have very high nutrient surpluses and low nutrient use efficiency, leaving ample opportunity for reducing nutrient losses from agriculture. Other countries have close to zero nutrient surpluses and high nutrient use efficiency, and in this case agricultural soils are being depleted of nutrients due to insufficient nutrient inputs, causing low yields as in the case of much of Sub-Saharan Africa. In these cases, nutrient inputs should be increased to improve productivity even if this is accompanied by small increases in nutrient losses to the environment (Zhang et al. 2015, UNEP 2022a). The analysis by Zhang et al. (2015) provides an example of how halving N surplus globally can take these regional differences into account while maintaining food security. For example, their proposed target for China is a reduction in annual N surplus by over 70% (from 38 million tonnes N in 2015 to 11 million tonnes N in 2050) combined with an increase in food production by over 20%, whereas the target for Sub-Saharan Africa allows for a doubling of N surplus (from 2 million tonnes N to 4 million tonnes N) while also doubling food production.

While increasing food production in countries with low nutrient use is critical, every effort should be made to avoid the trajectory followed by most OECD countries: a significant drop in nutrient use efficiency (and thus increase in nutrient losses) as nutrient application rates increase, followed by an increase in nutrient use efficiency as a blend of management practices, fertilizer technologies and crop breeding advancements become broadly adopted (Zhang et al. 2015). As fertilizer use and its use efficiency vary significantly among countries based on factors like climate, cropping patterns, economies etc., a thorough assessment of nutrient balances should be made such as those in the European N assessment (Sutton et al. 2011), Indian N assessment (Abrol 2017) and Pakistan N assessment (Aziz 2021). The livestock sector is the least efficient sector in terms of nutrient use, contributing greatly to nutrient pollution. The UN Economic Commission for Europe (UNECE) has adopted a guidance document on integrated sustainable N management providing a number of strategies to increase N use efficiency (UNECE 2021). Such guidance documents should also be prepared for phosphorus.

- ***including by reducing…" pesticides by at least two thirds"***

Global pesticide use and risks are increasing (Bernhardt et al. 2017, Schulz et al. 2021), with agriculture having by far the largest share (Maggi et al. 2019). Pest management in agriculture is essential to avoid potentially high yield losses from pests (Savary et al. 2019). Synthetic pesticides are just one of the solutions in the pest management toolbox, but most agricultural systems currently rely heavily on synthetic pesticides. Alternatives include biological solutions (e.g., biocontrol, bio-pesticides), agronomic solutions (e.g., adapted crop rotations, field hygiene), technical solutions (e.g., tools for precision application, mechanical weed control, smart farming), breeding solutions (e.g., resistant and adapted varieties) and system redesign (e.g., systems that favor natural solutions for pest control, see Möhring et al. 2020a for an overview). In principle, pesticides applied in agriculture follow registration procedures that ensure concentrations present in the non-target environment or reaching humans remain below those considered harmful, based on threshold values defined in ecotoxicological and toxicological testing programmes for each single pesticide. However, monitoring data for certain types of pesticides show that the concentrations regularly present in the environment greatly exceed the ecotoxicological thresholds determined in the regulatory pesticide risk assessment (Stehle & Schulz, 2015; Wolfram et al. 2018). These data are however largely restricted to surface waters, since we lack comprehensive monitoring for many terrestrial ecosystem components including biota.

<u>Target formulation</u> - The toxicity of pesticides varies greatly, and for example spans more than 12 orders of magnitude across insecticides and classes of aquatic invertebrates (Schulz et al. 2021). This means that some pesticides are highly toxic even at extremely low application rates, so pesticide quantity is not indicative of its risks. Highly toxic neonicotinoid insecticides for example only require application rates of a few grams per hectare, while older organophosphate insecticides are applied at rates of up to two kilograms per hectare. Toxicity to non-target organisms greatly depends on the type of pesticides and species group; insecticides are more relevant for pollinators and aquatic invertebrates, and herbicides are more relevant for plants (Schulz et al. 2021). **Any pesticide target based only on total pesticide mass applied in agriculture ignores the large range in toxicity**. For example, insecticide risk for aquatic invertebrates (driven by pyrethroids) or pollinators (driven by neonicotinoids) increased up to a factor of four in the USA between 1992 and 2016, while the applied insecticide amount decreased by about 40% (Schulz et al. 2021). Policies based on purely quantitative indicators (e.g., pesticide mass used) might therefore have unintended effects on risk reduction and might even result in incentives to use pesticides in lower quantities but with higher toxicity (Möhring et al. 2019). **It is of utmost importance to base pesticide policies and indicators on the toxicity of pesticides applied, or more generally on the risk associated with their application.**

Indicators for pesticide risk reduction should generally be applied at the level of pesticide sales or use to include all adverse impacts. Adverse impacts of pesticides include large field-level effects on non-target organisms such as pollinators and soil organisms, as well as effects of pesticides in non-target ecosystems that occur for example through spray drift or edge-of-field runoff (Beketov et al. 2013, Liess et al. 2021, Wolfram et al. 2021). Therefore, **the objective Target 7 should not be interpreted as being restricted to "pesticides lost to the environment".**

Numerical objectives, indicators and relationship to SDGs - Pest management plays an essential role in maintaining food security and agricultural incomes. Reducing pesticide risk can be achieved by 1) increasing the efficiency of current pesticide use, 2) substituting high risk with low risk pesticides and other pest management tools and 3) redesigning production systems (e.g. Pretty, 2018). **Literature and experiences from case studies show that increasing efficiency and substitution can achieve risk reduction of 20-50%**, **without redesign of production systems** (e.g., Lechenet et al. 2017, Kudsk et al. 2018, Möhring et al. 2020). Denmark, for example, was able to substantially reduce pesticide risks through the application of a risk based indicator in policies, even though quantitative indicators for total pesticide use increased (see Kudsk et al. 2018 for a description of relevant governmental sources).

Redesign of agricultural systems as well as novel pesticide-free production systems can greatly reduce pesticide use while increasing farmer's incomes and reducing trade-offs with yield losses compared to organic agriculture (Möhring and Finger 2022). The globally heterogeneous and context-dependent production potential of organic agriculture, i.e., using zero synthetic pesticides, shows that redesigning production systems might only lead to small yield losses for some production contexts and regions, but can be substantial for other regions and cropping systems (Seufert & Ramankutty 2017).

Transformation of pest management systems should therefore aim to reduce trade-offs and increase synergies with biodiversity to support pest control and productivity. For example, the trade-offs between increased mechanical weed control and soil erosion, or between reductions in agricultural productivity and the expansion of agricultural land or reductions in food security. Enhancing biodiversity in agricultural systems can help to greatly reduce pesticide inputs and should play an important role in redesign (Gurr 2016, Pretty 2018, Sattler 2021). Widespread adoption of sustainable pest management practices that are drastically reducing pesticide use or are pesticide-free will therefore require novel technologies, techniques and programs, as well as changes in food diets and food waste to compensate for potential yield reductions (Muller et al. 2017, Pretty 2018). Long-term and stable planning horizons for such changes will enable food-value chain actors to adapt and reduce trade-offs (Möhring et al. 2020). Further, food-value chain actors will play an important role in supporting this transformation to provide pathways for reducing potential trade-offs with food production, farmers incomes, soil conservation and greenhouse gas emissions (Möhring et al. 2020).

Adapting objectives to national contexts - Some countries have extremely high pesticide use and risks, others currently use very little pesticides (Tang et al. 2021, Appendix-Figure 1 and Maggi et al. 2021, Appendix-Figure 4). As such, **global numerical objectives for reduction of pesticide risk should not be applied directly to national levels, and should instead be based on evaluations of current pesticide use and risk, capacity for reducing risk and short- and long-term trade-offs.** Moreover, the entry routes into non-target ecosystems and in consequence the type of pesticides causing the main problems will differ between countries. Herbicide use has often the largest share of pesticide use and likely poses risks to terrestrial non-target plants, while insecticides are used in much smaller quantities, yet pose risks to many non-target invertebrates due to their tremendous toxicity (Schulz et al. 2021). Risk mitigation measures to account for the different entry routes have been proposed (Stehle et al. 2011).

3) Indicators

- **Indicators in GBF monitoring framework** (pre-SBSTTA 24, notes from SBSTTA-24 in {})

Headline in bold, component indicator in plain and *complementary indicator in italics*

7.0.1 Index of coastal eutrophication potential (excess nitrogen and phosphate loading, exported from national boundaries) / Disaggregation by water body type {or by basin}

7.1.1 Fertilizer use (FAO {SDG 14.1.1a})

7.1.2 Proportion of domestic and industrial wastewater flow safely treated (SDG 6.3.1)

{7.4.1 Municipal solid waste collected and managed (SDG 11.6.1)} *t7.1 Trends in Loss of Reactive Nitrogen to the Environment*

7.0.3 Pesticide use per area of cropland / Disaggregation by broad pesticide use classes

➢ Comments on nutrient indicators

Measuring progress on reducing nutrient pollution requires numerous indicators given the multiple sources and impacts of nutrient pollution (Appendix-Figure 3). In general, sets of **indicators that focus on the point of use or loss (e.g. nutrient use efficiency; nutrient surplus; NO_x emissions from agriculture, transport and industry) are more helpful for informing policies to reduce pollution than sink-specific indicators such as N and P export to coastal areas from rivers, which is the current headline indicator** (Kanter et al. 2020, Quan et al. 2021, Raza et al. 2018). Moreover, a focus on one specific nutrient compound can increase the risk of pollution swapping, where actions to mitigate losses of one form of nutrient pollution leads to increases of another form (Stevens & Quinton 2009, Bouraoui & Grizzetti 2014).

The current GBF monitoring framework covers a small and piecemeal range of relevant nutrient pollution indicators, and the headline indicator covers only one part of important N and P pollution sinks (Appendix-Figure 3). This can only partially be improved because readily available indicators covering key sources and sinks of pollution with global coverage are lacking. It is, however, strongly recommended that the GBF complement the current set of indicators focusing on fertilizer use, coastal eutrophication potential and wastewater treatment, which capture only a narrow range of nutrient pollution impacts or potential implications of different policy actions. In particular, **indicators focusing on agricultural N and P surplus (= total N or P input minus the amount taken up by crops or pasture grasses) are available and more relevant than fertilizer use for assessing progress on agricultural sources of N and P pollution.** National-level data on N and P surpluses are documented in Zhang et al. (2021b) and Zou et al. (2020), respectively, and can be calculated from FAO data. Transdisciplinary and transnational collaboration is needed to improve the basic data (such as the quantification of nutrient budgets) for these indicators (Zhang et al 2021a).

There are several other indicators that might be considered including: N footprint (Shibata et al. 2017, Galloway et al. 2014) and the Sustainable Nitrogen Management Index (SNMI, used in the SDG Dashboard and the Environmental Performance Index; Zhang and Davidson 2019), which is defined based on two efficiency terms in crop production, namely Nitrogen Use Efficiency (NUE) and land use efficiency (crop yield).

➢ Comments on pesticide indicators

Several indicators of risk-based pesticide use have recently become available. These indicators provide different and complementary insights into pesticide risks for biodiversity and associated risks for the environment and human health, and should be used in combination to evaluate progress on Target 7.

Generally the basic requirement to compute aggregated risk indicators is data on pesticide sales or use on a product or active substance level, combined with data bases containing information on risk per product or active substance. Data for pesticide sales at a product level are available in almost every country through taxation or customs data (import/export). Data on risk per product or active substance is for example compiled in the Pesticide Properties Database and regularly updated (Lewis et al. 2016). More precise assessments of impacts require more detailed data on pesticide use and exposure on a product level, which is still very scarce even in regions with explicit pesticide risk reduction targets (e.g., Mesnage et al. 2021). For example, Denmark is using an indicator of potential pesticide risks, the Pesticide Load Indicator, on a national level with low administrative burdens and costs since 10 years (Kudsk et al. 2018).

Pesticide risk specifically focusing on biodiversity can be estimated for a wide range of species groups including aquatic and terrestrial plants, invertebrates and vertebrates based on toxicity data (Total

Applied Toxicity, Appendix-Box 1, Schulze et al. 2021). The input data needed are substance-specific pesticide use data based on sales at the country level as well as pesticide toxicity data which are publicly available for a large number of compounds (>380) and eight species groups (Schulz et al. 2021). This can be accompanied by an indicator of human health risk.

Pesticide risk evaluation of environmental risk using toxicity measurements on model organisms (fish, earthworms and rats) can be quantified by the Risk Score (RS, Tang et al. 2021, Appendix-Figure 1 and Box 1). This can be accompanied by an indicator of human health risk reduction using the Pesticide Health Risk Index of Countries (PHRIC, Maggi et al. 2021). Definitions and details can be found in Appendix-Box 1. RS and PHRIC require knowledge of the applied mass of and toxicity of individual active ingredients, crop type and several environmental parameters. Countries that do not collect this data may rely on to use estimates from FAOSTAT or other publicly accessible (peer reviewed) sources such as PEST-CHEMGRIDS (Maggi et al. 2019). An additional indicator, the surface area of agricultural land that is at risk of pesticide pollution, might also be considered and is based on the same methodology (Tang et al. 2021).

4) Linkages to other relevant international policies

The nutrient and pesticide pollution objectives of the GBF are broadly coherent with other international policies. There are thousands of nutrient and pesticide policies in place at local, national and supra-national levels that vary greatly in their objectives, so striving for greater coherency across policies is vital (Kanter et al. 2020, Möhring et al. 2020). Unfortunately, only a few of the many policies aimed at reducing nutrient and pesticide pollution have reached their objectives and globally nutrient and pesticide pollution are rising (SCBD 2020). Kanter et al. (2020, nutrients) and Möhring et al. (2020, pesticides) provide analyses of the reasons for failure and success of policies, and find that setting clear goals, choosing appropriate performance indicators and systemic approaches involving all actors are common denominators to help ensure success.

Nutrients

- Colombo Declaration (2019): Develop national roadmaps for sustainable nitrogen management, with an ambition to halve nitrogen waste by 2030;
- UNEA-4 and UNEA-5, Resolution on Sustainable Nitrogen Management (2019, 2021): ambition to significantly reduce nitrogen pollution by 2030 by covering all the spheres of the nitrogen cycle, potentially supported through the establishment of an inter-convention or intergovernmental nitrogen coordination mechanism. The ambition is to reduce nitrogen waste to combat pollution, climate change and biodiversity loss, while ensuring food security and offering the potential to save billions of United States dollars annually.
- See Kanter et al. (2020) for global database of N policies (mostly national) revealing a clear tension between policies that facilitate and/or directly encourage N use with a view towards food security, and policies that put constraints on N use and/or losses to the environment.

Pesticides

- UNEA Resolution ¾: Environmental and Health Impacts of Pesticides and Fertilizers and ways to Minimize Them. Synthesis Report (2021).
- Basel, Rotterdam, Stockholm Conventions (BRS), and the Minamata Convention on Mercury (MC): The 1998 Rotterdam Convention on the Prior Informed Consent Procedure for certain Hazardous Chemicals and Pesticides in International Trade is particularly pertinent for the pesticide objective. A 2021 policy brief on the relationships of this convention and the Basel and Stockholm Conventions to the GBF can be found at this link Interlinkages between the chemicals and waste multilateral environmental agreements and biodiversity: Key insights
- Example from the European Union of two policies covering pesticides: the Farm to Fork—to reduce by 50% the use and risk of chemical pesticides by 2030—and Biodiversity Strategies—reduce by 50% the use of more hazardous pesticides by 2030.

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TARGET 7–POLLUTION - APPENDIX

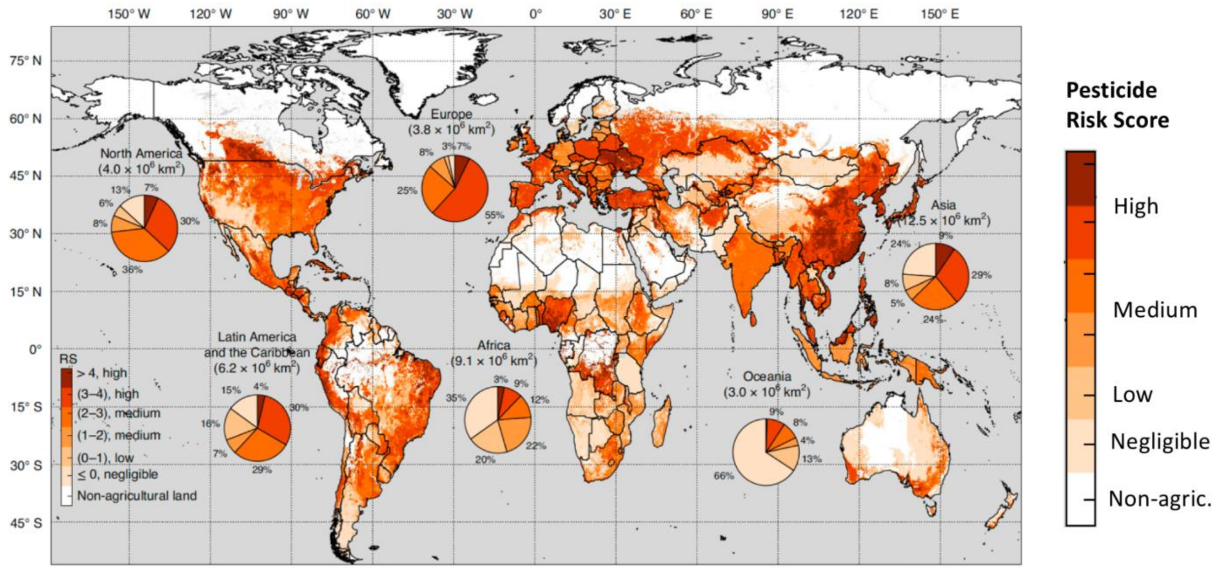


Figure 1. Global scale map of pesticide risk. "64% of global agricultural land is at risk of pesticide pollution by more than one active ingredient, and 31% is at high risk. Among the high-risk areas, about 34% are in high-biodiversity regions." Tang et al. (2021, see also description below in Box 1)

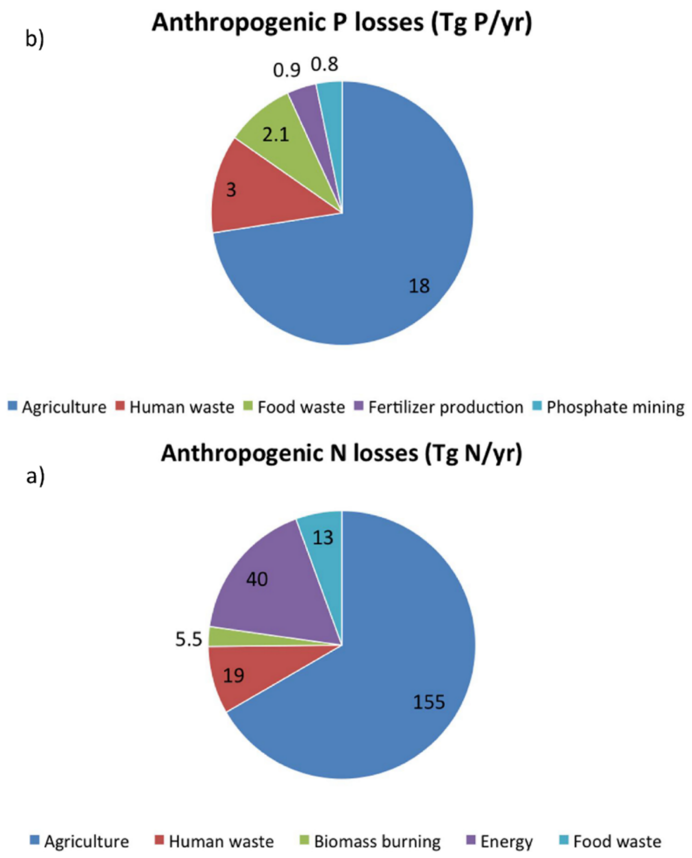


Figure 2. Sources of nitrogen (N) and phosphorus (P) losses to the environment at the global scale. from Kanter & Brownlie (2019)

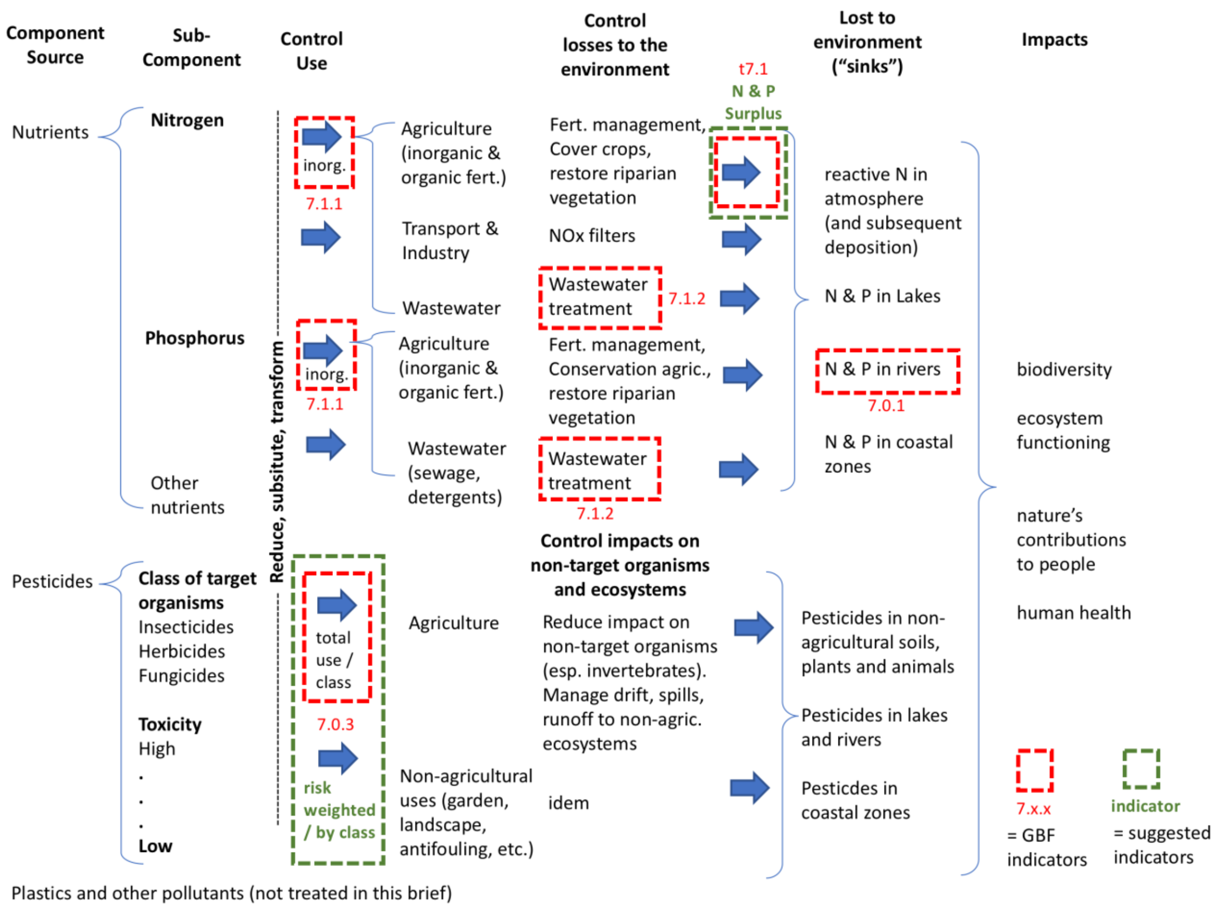


Figure 3. Summary of sources of nutrient and pesticide pollution; means of reducing pollution by controlling use or losses to the environment; proposed indicators for the GBF; and impacts. Indicators currently in the GBF are in red boxes. The headline indicator for nutrients is N and P in rivers lost to coastal areas (7.0.1). The only indicator for pesticides is total pesticide use (7.0.3). This brief suggests using N and P surplus as the headline indicator for nutrient pollution and risk based pesticide use as the primary indicator for pesticides (green boxes).

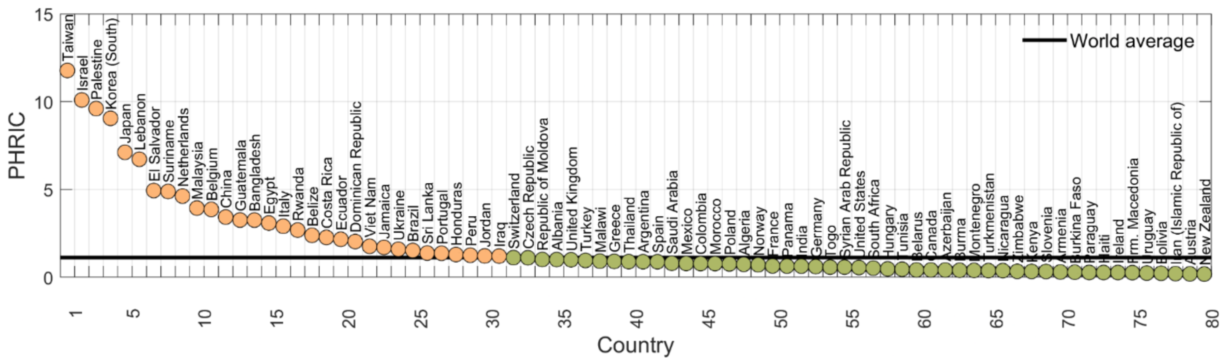


Figure 4. Pesticide health risk index of countries (PHRIC). 31 countries worldwide have PHRIC higher than the world average, where PHRIC aggregates the pesticide load (toxicity and mass), people exposure, and potential intake via inhalation and drinking water (Maggi et al. 2021).

Table 1. Summary of most important impacts of nutrient (nitrogen and phosphorus) pollution on biodiversity

Impact	**Caused by**	**Indicators**	**Safe limits[3]**
Freshwater eutrophication	- Increased and N and P discharge to surface water (from point sources, surface- and subsurface runoff) - Reduced streamflow	- N / P concentration in rivers, lakes and streams	- Nitrogen: 1-4 mg N l-1 - Phosphorus: 0.05-0.1 mg P l–1 - Variation across water bodies which nutrient is most limiting
Coastal eutrophication	- Increased and N and P delivery to coastal waters	- N & P concentrations in river discharge to coastal waters - ICEP - Chlorophyll a concentrations	
N enrichment impacts on terrestrial ecosystems (including acidification, micronutrient deficiencies, shifts in species composition	- Increased air emissions of reactive N (NH3+NOx) and consequent re-deposition onto terrestrial ecosystems	- Total N deposition in relation to an ecosystem's carrying capacity (critical load) - NO3- in soil solution	- Ecosystem-dependent critical loads (10-30 kg N ha-1 yr-1) - The duration of exceedances is also relevant
Direct damage to plants from NH3, NO2 or O3 exposure	- Increased air emissions of reactive N (NH3+NO)	Exposure to increased NH3 / NO2 / O3 concentrations	- NH3 in air: 1-3 µg NH3 m-3 - NO2 in air: 15-30 µg m-3 - Ozone: Growing-season AOT40 of 10 ppm/hour

Other N and P impacts not included in table:

- N contribution to particulate matter (PM2.5 + PM10) formation (relevant for human health, but impact on ES less well known)
- N contribution to stratospheric ozone depletion via N2O (relevant for human health, but impact on ES less well known)
- Nitrate pollution of groundwater (mainly relevant for human health)
- N contribution to climate change (climate change important driver of BD loss but N plays minor role and climate considered in other targets)

[3] Freshwater eutrophication: Poikane et al. 2019, Camargo & Alonso / Coastal eutrophication: Brooks et al. 2016, Garnier et al. 2010 / Terrestrial N enrichment: Bleeker et al. 2011, Bobbink et al. 2010, Payne et al. 2017 / Air pollution: Cape et al. 2009, Krupa 2003

Table 2. Summary of most important impacts of pesticide pollution on biodiversity. Reductions in applied pesticide toxicity are not well defined (see Box 1); however, the scarce data available indicate that strong reduction in applied toxicity is needed to ensure environmental and human health. It is however of utmost importance that an overall reduction in the applied toxicity for all relevant species groups is ensured, and current-use toxic pesticides are not just simply replaced by others that are toxic to another species group. (Jactel et al. 2019)

Impact	**Caused by**	**Indicators**	**Safe limits**
Surface water [and marine] biodiversity (structure and function)	- Point and nonpoint source entry - Direct exposure - Accidents - Main focus on insecticides: Pyrethroids, some OPs for aquatic invertebrates and fish	- Toxicity of pesticides applied (separated for species and compound groups) - Pesticide concentration in rivers, lakes, streams, [and coastal areas] (water, sediment, and biota)	- Critical limits not well defined from the standpoint of biodiversity (see Table legend, Box 1). - Concentrations of individual active ingredients or their breakdown compounds should not exceed regulatory threshold levels
Terrestrial biodiversity (structure and function)	- Direct exposure - Point and nonpoint source entry - Accidents - Main focus on insecticides and herbicides: Neonicotinoids for pollinators; Amino Acid synthesis inhibitors and cell membrane disruptors for terrestrial plants	- Toxicity of pesticides applied (separated for species and compound groups) - Pesticide concentration in terrestrial non-target ecosystems (plants, insects, vertebrates, other biota)	- Critical limits not well defined from the standpoint of biodiversity (see Table legend, Box 1). - Concentrations should not exceed regulatory threshold levels
Soil biodiversity (structure and function)	- Direct exposure - Point and nonpoint source entry - Accidents - Main focus on fungicides and insecticides: Azole fungicides and specific insecticides	- Toxicity of pesticides applied (separated for compound groups) - Pesticide concentration in terrestrial non-target ecosystems (plants, insects, vertebrates, other biota)	- Critical limits not well defined from the standpoint of biodiversity (see Table legend, Box 1). - Concentrations should not exceed regulatory threshold levels

Other pesticide impacts not included in table: effects on human health

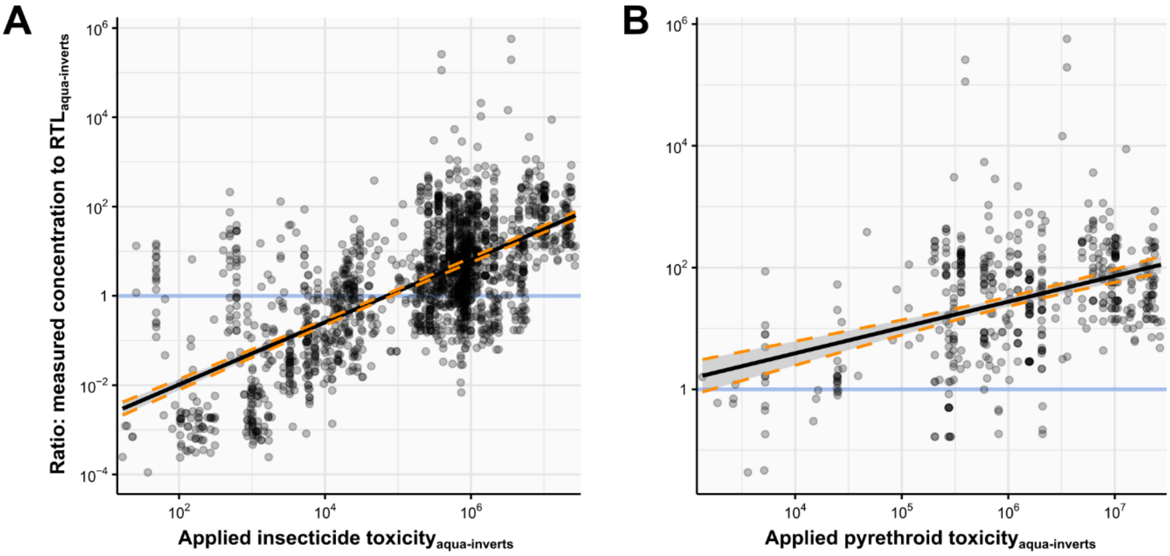
------------------------------ Box 1. Risk based indicators for pesticides —-----------------------

Environmental and human risk indicators - The Risk Score (RS) defined in Tang et al., (2021, see Appendix Figure 1) considers pesticide contamination of soil, surface water, ground water and air with an explicit accounting for environmental toxicity and degradation half-time. The Pesticide Health Risk Index of Countries (PHRIC) defined in Maggi et al, (2021) is a composite index including the applied mass of pesticides, their toxicity load, and human exposure and intake. RS and PHRIC require knowledge of the applied mass of individual active ingredients and the crop type. It is therefore critical that countries take initiatives to monitor and keep records of applied mass, timing and location (at least at the level of administrative units) for the purpose of quantifying the risk and analyze trends to achieve reduction of risk. Countries that do not collect data or are not in the position to do so may need to use estimates from FAOSTAT or other publicly accessible (peer reviewed) sources such as PEST-CHEMGRIDS (Maggi et al., 2019). Data quality of inputs and risk analyses may be improved when data have finer granularity (administrative units) in contrast to country totals. Countries may also monitor detrimental effects of not using or using in substantially lower amounts pesticides for food/fiber production.

Biodiversity-oriented risk indicators – Any pesticide risk indicator must, in order to help to reduce risks, at the end of the day lead to reduced concentrations of those types of pesticides most relevant, i.e. most toxic, to the different groups of species. It is therefore important to evaluate whether a lower risk indicator indeed leads to a lower exposure and thus risk in those ecosystems to be considered. The Total Applied Toxicity, TAT (Schulz et al. 2021) has up to now been calculated for eight groups of non-target organisms (aquatic invertebrates, fish, aquatic plants, terrestrial invertebrates, pollinators, birds, terrestrial mammals, and terrestrial plants). TAT simply multiplies the total use of pesticide active ingredients with the reciprocal of toxicity thresholds from the regulatory pesticide toxicity testing (RTL = Regulatory Threshold Levels; Stehle & Schulz 2015). In other words, the only thing TAT does, is to express pesticide use instead of amounts applied in terms of toxicity applied, separated for groups of pesticides and species. TAT does, in contrast to other risk indicators, such as the Risk Score (RS) defined in Tang et al., (2021) or the SYNOPS risk calculator used in the German National Action Plan (Strassemeyer et al. 2017), not attempt to estimate the transport of pesticides into the non-target environment.

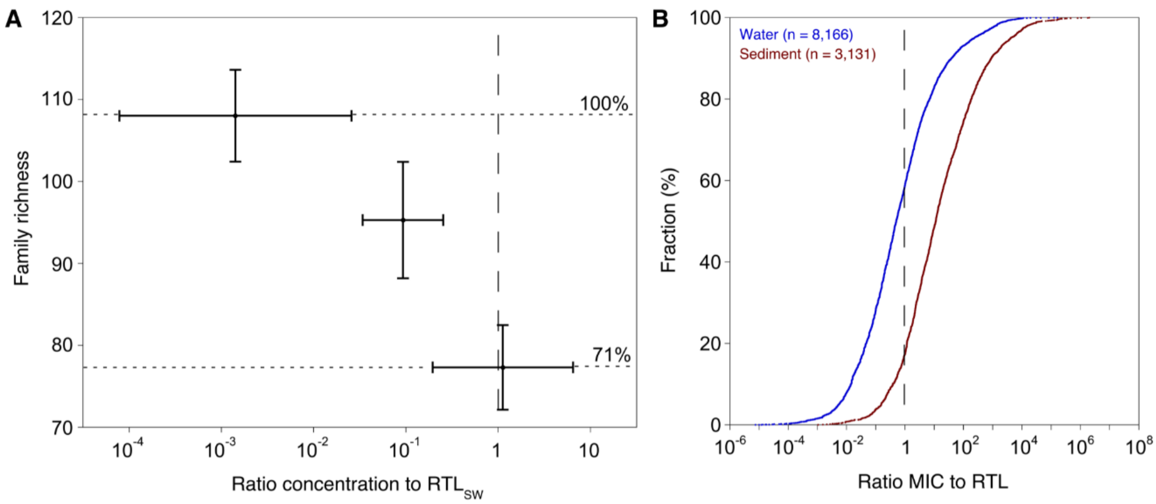
Although studies have shown that toxicity-weighted use is the strongest predictor of the potential impact of a pesticide on the environment, TAT relies on the assumption that pesticide use and its effects on organisms are robustly connected to each other at large scales (Schulz et al. 2021). This assumption is, however, been supported by data from the USA, even in the crucial case of pesticide and pyrethroid risks to aquatic invertebrates. The rate at which measured insecticide or pyrethroid concentrations exceed the RTL for aquatic invertebrates is significantly correlated with the applied toxicity (see figure below). This kind of analysis can, however, up to now only be made for surface waters, since the relevant data are lacking for all other ecosystems.

Both pesticide use and toxicity can then be computed very simply to come up with Total Applied Toxicity estimates, separated for pesticide type, organism group, ecosystem type, or cropping system. Calculations of, as a toxicity based indicator, can be done in any standard table calculation software and the low complexity of the input data eases transparency, understanding and interpretation of any risk-related outcomes.



Relationship between the aquatic invertebrate threshold level exceedance of insecticide (A) or pyrethroid (B) concentrations measured in U.S. surface waters and the total applied insecticide toxicity (Schulz et al. 2021).

Other studies have shown RTL-exceedances of pesticides in surface waters to be indicative of negative effects on aquatic biodiversity (Stehle & Schulz, 2015). The family richness of aquatic invertebrates is reduced by ~30% when the RTL is exceeded (see figure below). The RTL is exceeded in more than 40% of the insecticide concentrations quantified in the water phase and in more than 80% of those quantified in sediments (Stehle & Schulz 2015), illustrating how widespread the problem is (see also Tang et al. 2021).



(A) Observed ecological effects of insecticide exposure on regional surface water biodiversity and (B) distribution curves for global reported measured insecticide concentrations (MICs) in water and sediment relative to regulatory threshold levels (RTLs). The vertical dashed line indicates the RTL (Stehle & Schulz 2015).

It is important to note that only very few groups of pesticides or even very few individual pesticides drive large proportions of the TAT. In the case of aquatic invertebrates, only four pyrethroid compounds explain >80% of the TAT increase observed for this species group in the USA (Schulz et al. 2021). This fact comes along with the advantage that regulating only few compounds or pesticide groups may reduce the risks considerably, yet only under the assumption that the reduced use is not compensated by other pesticides, which then will increase the TAT again.

TARGET 8 – CLIMATE CHANGE

Background on the science briefs

The bioDISCOVERY programme of Future Earth and the Secretariat of the Group on Earth Observations Biodiversity Observation Network (GEO BON), convened a group of experts to prepare six briefs to provide scientific support for the negotiations of the post-2020 global biodiversity framework (GBF) at the fourth meeting of the Working Group on the Post-2020 Global Biodiversity Framework in Nairobi, from 21 to 26 June 2022. This includes four briefs on individual targets 3, 7, 8 and 10; a brief on the GBF monitoring framework; and a brief on the ecosystem area and integrity objectives of the GBF that also addresses targets 1 and 2 in detail.

The analysis in this brief focuses on the wording and quantitative elements of target 8, definitions of key terminology, and assessment of the adequacy and availability of indicators for tracking achievement of this target.

This analysis is based on the text of the first draft of the post-2020 global biodiversity framework, CBD/WG2020/3/3 and subsequent negotiations of this text:

> ***Target 8. Minimize the impact of climate change on biodiversity, contribute to mitigation and adaptation through ecosystem-based approaches, contributing at least 10 GtCO$_2$e per year to global mitigation efforts, and ensure that all mitigation and adaptation efforts avoid negative impacts on biodiversity***.

Structure of this brief

- Key messages (1 page summary)
- Background
  1) Relevance for biodiversity, nature's contributions to people and good quality of life
  2) Target formulation, numerical objectives, indicators and impacts on SDGs
  3) Indicators
  4) Linkages to other relevant international policies
  5) References
- Appendix – Graphics, tables and short texts in support of the background material

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KEY MESSAGES CONCERNING THE CLIMATE CHANGE OBJECTIVES OF TARGET 8

Minimize the impact of climate change on biodiversity

- Keeping climate change to the Paris Agreement objectives of "well below 2°C, and as close as possible to 1.5°C" is essential to achieving the GBF objectives. Even at these levels, climate change will increase extinction risk, cause large shifts in species distributions, alter ecosystem functioning, and compromise nature's contributions to people.
- Improving the resilience of species and ecosystems in the face of climate change is essential. This can be achieved by reducing additional and interacting pressures on biodiversity from land and sea use change, overexploitation, invasive alien species and pollution.
- Spatial planning to protect large areas of intact ecosystems and increase connectivity in multifunctional land and sea-scapes is crucial for climate change adaptation because it will facilitate species range shifts in response to climate change.

Mitigation and adaptation through "ecosystem-based approaches" / "nature-based solutions"

- The conservation and restoration of nature can significantly contribute to climate mitigation. For example, the protection of intact ecosystems and restoration of degraded ecosystems are among the most rapid and cost-effective means of climate mitigation, and can provide a range of other benefits.
- Protecting and restoring natural ecosystems helps species, ecosystems and people to adapt to climate change. For example, protecting and restoring coastal wetlands, mangroves and coral reefs enhances the capacity of socio-ecosystems to adapt to rising sea levels.
- Increasing the integrity of ecosystems used for agriculture, forestry and fisheries, in particular through management practices that reinforce biodiversity, can greatly improve the capacity of these ecosystems and people to adapt to climate change.
- Clear definitions and bounds on ecosystem-based approaches / nature-based solutions for climate are needed to avoid perverse effects on nature and people, and focus should be on measures that provide "wins" for climate, biodiversity and human well-being. Involvement of local actors is essential, taking into account all forms of relevant information, including scientific, cultural and local knowledge, innovations and practices.
- Failure to greatly reduce emissions from all sectors including energy, transport and agriculture will increase climate risks for natural systems and compromise their contributions to mitigation.

Quantitative objective for climate mitigation

- A combination of nature-based solutions / ecosystem-based approaches to mitigation can potentially provide between 5 and 10 $GtCO_2e$ per year mitigation cost-effectively, without compromising production of food and fibre, and with strong safeguards for biodiversity. Achieving these levels of mitigation requires substantial reductions in loss and degradation of natural ecosystems, and large increases in restoration compared to the period 2010-2020. It is essential to note that respecting these safeguards and achieving the high-end estimate of 10 $GtCO_2e$ per year requires ambitious and deep systemic changes in production and consumption, and is broadly consistent with a 5% net gain in natural ecosystems by 2030.
- Setting an ecosystem-based mitigation target in the GBF would be an important complement to goals in the UNFCCC, because it more explicitly stipulates safeguards for biodiversity.

Avoiding negative impacts of mitigation and adaptation efforts on biodiversity

- Competition for land, in particular arising from climate mitigation based on large-scale afforestation and bioenergy production, could be particularly detrimental for biodiversity. Adverse impacts on biodiversity arising from technological measures for adaptation such as construction of dams, seawalls and new irrigation capacity for agriculture should also be avoided.
- Mitigation and adaptation interventions must be well designed and implemented in order to avoid adverse impacts on nature and people, emphasizing equity and social justice.

BACKGROUND ON THE CLIMATE ADAPTATION AND MITIGATION OBJECTIVES OF TARGET 8

1) Relevance for biodiversity, nature's contributions to people and good quality of life

Minimizing the impact of climate change on biodiversity requires prevention of further loss of natural habitats and native species, restoring ecosystems to a natural condition, and sustainable use of natural resources (Pörtner et al. 2021, Costello et al. 2022, Shin et al. 2022). These same actions are critical to ensure biodiversity support of climate mitigation and adaptation (Pörtner et al. 2021).

There is robust evidence that climate change is already impacting biodiversity and ecosystem processes in marine, terrestrial and freshwater realms and that these impacts are projected to substantially increase over the coming decades (Arneth et al. 2020, Pörtner et al. 2021, IPCC 2022a; see Appendix – Figure 1 for a summary). A significant portion of marine, aquatic and terrestrial species may face risk of extinction during this century as a result of climate change (Arneth et al. 2020, IPCC 2022a). Further, such impacts will interact with other drivers of change in biodiversity and ecosystem services (this is also critical in terms of relevance of this target to other targets, and vice versa). Finally, **climate change is projected to overtake the pace of other drivers of biodiversity loss in the next few decades in some regions, even in low greenhouse gas emissions scenarios** such as RCP 2.6 by 2050 (Arneth et al. 2020, IPCC 2022a).

The benefits of conserving and restoring biodiversity in the context of climate change are multiple (Arneth et al. 2021, Mori 2020, Mori et al. 2021, Pörtner et al. 2021, Shin et al. 2022, IPCC 2022a):

- Significant carbon is stored in soils, sediments and living biomass in terrestrial, coastal, and marine ecosystems, and release of this carbon into the atmosphere, which is amplified through biodiversity loss, needs to be minimized.
- The capture of greenhouse gases by living organisms from the atmosphere and water reduces climate forcing (e.g., warming), and increases these carbon stores (e.g., potential in global forests; Mori et al. 2021, Pörtner et al. 2021). Terrestrial ecosystem CO_2 uptake is large, and is key in climate change mitigation scenarios (Arneth et al. 2020, IPCC 2022a, IPCC 2022b). How ecosystems transfer carbon into the sedimentary stores is complex and involves many uncertainties, particularly in relation to long term storage, which is essential for effective mitigation (IPCC 2022a).
- **Ecosystems generate multiple contributions of nature to people, in addition to their climate-related benefits. Target actions must thus be designed to suit local ecological and social conditions, with explicit involvement of local communities to co-design and implement actions that assure co-benefits for climate mitigation, climate adaptation and nature's contributions to people**, and to prevent potential negative impacts (Pörtner et al. 2021).

Protecting biodiversity and avoiding dangerous climate change are complementary within the mandates of the Convention on Biological Diversity (CBD) (this biodiversity framework), and the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC)—and both are intended to help countries deliver a good quality of life for all people under the UN Sustainable Development Goals (SDGs). Target framing must address these joint policy spheres to assure a multiple benefits approach—ideally, with "win-win-win" delivery of biodiversity gains, support of climate mitigation and adaptation, and benefits to people that are equitably delivered.

2) Target formulation, numerical elements, indicators and impacts on SDGs

Target 8 was analysed in this brief by breaking it down into its individual components. This is similar to the approach used for the Aichi Target analyses in the Global Biodiversity Outlooks 4 and 5, as well as the "one-pager" summaries of the GBF goals, milestones and targets (CBD/WG2020/3/INF/3).

➢ ***Minimize negative impacts of climate change on biodiversity***

Climate change impacts on species occur at a range of scales (from genes and individuals to populations), at habitat and ecosystem scales, they may occur through changes in interspecies interactions (e.g., competition, predation or disease), and through community composition (Scheffers et al. 2016), ecosystem function and ecosystem structure (See Appendix – Figure 1; Arneth et al. 2020; Pörtner et al. 2021). **Other anthropogenic pressures and direct drivers—including land/sea-use change, direct exploitation of organisms, pollution and invasive alien species—interact with climate change, often aggravating climate change impacts on biodiversity and ecosystem function and may collectively create large-scale regime shifts that are very difficult to reverse** (Arneth et al. 2020, Pörtner et al. 2021, IPCC 2022a). It follows that such drivers must be addressed in addition to attention to climate change.

Further, **conservation actions need to be made more 'climate smart'** (e.g., Arafeh-Dalmau et al. 2021, Pörtner et al. 2021, Brito-Morales 2022); in part through increasingly applying climate change vulnerability assessments of species, ecosystems and protected areas; but also addressing non-climate (interacting) drivers (see above, and below). **Static biodiversity conservation targets that do not take climate change scenarios into account will fall far short of achieving their objectives over the next few decades** (Arneth et al. 2020). One of the challenges is that the nature of climate impacts on biodiversity and ecosystem services is projected to lead to 'no analog' challenges (e.g., novel plant and animal interactions and communities) in biodiversity conservation, effectively requiring flexible, adaptable, evidence-based and dynamic approaches to conservation planning (Arneth et al. 2020). Such conservation actions would include attention to other (often interactive) drivers—for example, in marine and coastal areas, coordinated actions also addressing non climate stressors such as overfishing and direct damage to reefs. Finally, such actions must also be more culturally informed, societally inclusive and adaptive processes; avoiding the creation of so-called 'winners' and 'losers'—with a strong emphasis on social equity and justice (Pörtner et al. 2021).

➢ ***Contribute to mitigation and adaptation through ecosystem-based approaches***

<u>"Contribute to mitigation and adaptation"</u> – Ecosystem-based approaches can contribute to both mitigation and adaptation (e.g., Pörtner et al. 202, Shin et al. 2022; Smith et al. 2022, Appendix – Figures 3, 4 & 5); although, as indicated elsewhere in the brief, such approaches must be carefully designed and implemented, based on up-to-date evidence. Figure 5 in the Appendix (from Smith et al. 2022) shows a summary of impacts of a range of climate mitigation and adaptation practices based on land and ocean management that differ substantially in their benefits for climate mitigation and adaptation potential, as well as effects on biodiversity.

For example, **restoration and reduced losses of coastal wetlands could provide 0.3-3 $GtCO_2e\ yr^{-1}$ of climate mitigation, increase adaptive capacity for 100's of millions of people and benefit biodiversity** (See Appendix – Figure 5). Conversely, **afforestation could potentially provide high mitigation contributions if designed and managed carefully, but if done at scales needed to achieve these high contributions afforestation would likely have large negative impacts on biodiversity, little benefit in terms of climate adaptation capacity and compromise food security** (Pörtner et al. 2021, Shin et al. 2022, Smith et al. 2022, Appendix – Figure 5). In particular, monoculture tree plantations are of little benefit or even detrimental for biodiversity and do not provide significant adaptation benefits, and large-scale planting of trees in grasslands may often negatively impact biodiversity and ecosystem services, and may not provide sought after climate mitigation benefits (Pörtner et al. 2021).

Interventions focusing on climate mitigation can have positive synergies with adaptation, as well as benefiting biodiversity. The IPCC SRCCL report (IPCC 2019) for example, shows five options with large mitigation potential, and a further five with moderate mitigation potential that have either limited or no adverse impacts on other land challenges. These include improving carbon uptake potential through avoided conversion of natural land, and restoration; as well as improving yields through sustainable managing agricultural and forest lands (IPCC 2019, 2022a, 2022b, Smith et al. 2022). The latter also holds co-benefits for climate adaptation, as well-informed sustainable management of managed ecosystems can help improve the resilience of the agricultural and forestry sectors under future climate change (Pörtner et al. 2021; and see, for example, Hall 2019 and Mastretta-Yanes et al. 2018, demonstrating how genetic diversity provides a clear benefit in resilience and multiple benefits in livestock and domesticated plants and their wild relatives respectively).

Pörtner et al. (2021) provide numerous examples of nature-based solutions that can contribute to climate adaptation. These nature-based interventions typically come with important co-benefits for biodiversity and a wide range of ecosystem services, and many also help reduce risk in the face of uncertainty. Pörtner et al. found that "nature-based measures often focus on maintaining and restoring genetic and species diversity and abundance, or on preserving, restoring or creating healthy ecosystems." They also concluded that "**diversification of agricultural land use types, the genetic variety of crops, and tree species helps spread risk. Such diversification can make social-ecological systems more resilient to climate change and increase genetic, species and habitat diversity**. Current economic incentives within agriculture, forestry and fisheries, however, do not promote such diversification and fail to reflect the multiple ecosystem services that contribute to human well-being."

"Through ecosystem-based approaches" – There has been considerable debate during the negotiations of the GBF about the use of "ecosystem-based approaches", "nature-based solutions" and other terminology. This brief uses the terms "ecosystem-based approaches", "nature-based solutions", and for climate adaptation, "ecosystem-based adaptation" interchangeably, but acknowledges that they must be defined with clear safeguards for nature and people, and that these terms have different histories of use that colour their perception. The use of these terms in this target and the need for clear definitions are discussed briefly below, but there is not a strong scientific case for prioritizing one particular terminology.

The terms "ecosystem-based adaptation (EbA)", "ecosystem-based approaches" and "nature-based solutions (NbS)" have gained frequent usage in the context of employing ecosystems to mitigate climate change and/or increase the capacity of nature and people to adapt to climate change (Nalau and Verrall 2021; Pörtner et al. 2021). EbA and NbS are used even more broadly to refer to measures that address a range of challenges including food security, disaster risk and exposure, infrastructure, amongst others (Appendix – Figure 2, see section on indicators below). These terms are part of a larger set of terminology with similar, but not identical, meanings including "natural climate solutions" (e.g., Griscolm et al. 2017).

The term "nature-based solutions (NbS)", was formally adopted at UNEA-5 (2022, UNEP/EA.5/Res.5) and defined as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits." The resolution also calls for implementations of nature-based solutions to safeguard the rights of communities and indigenous peoples. The concept and use of NbS is controversial, including in the context of climate adaptation and mitigation, since NbS is sometimes used to refer to climate mitigation and adaptation solutions without adequate safeguards for biodiversity (Nesshöver et al. 2017, Seddon et al. 2020). In addition, NbS definitions often do not clearly specify the role of local communities in design and implementation (Seddon et al. 2020, UNEP & IUCN 2021, Welden et al. 2021). This has been addressed in the UNEA definition. EbA and NbS share much in common, but EbA more explicitly places an emphasis on participatory, local scale climate adaptation strategies that take into account social, economic and cultural benefits for local communities (CBD 2009).

"Ecosystem-based approaches" are defined as "the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way" and is an integral part of CBD terminology (CBD SBSTTA 2007). The implementation of ecosystem approaches has encountered a number of challenges (CBD SBSTTA 2007, Waylen et al. 2014), and while it rapidly gained usage in the scientific literature in the 1990's and early 2000's its use has waned considerably since (Waylen et al. 2014). The concept of "ecosystem approaches" has been interpreted and applied in widely different ways (CBD SBSTTA 2007, De Lucia 2015, Waylen et al. 2014,) and is "elusive, unstable and, importantly, contested" making it "susceptible to discursive capture by competing narratives" (De Lucia 2015). Thus, the term "ecosystem-based approaches" faces many of the same challenges as NbS, and must be carefully defined in the context of climate adaptation and mitigation strategies if it is used in the wording of Target 8.

- ***Contribute at least 10 GtCO$_2$e per year to global mitigation efforts***

Setting an ecosystem-based mitigation target in the GBF would be an important complement to climate mitigation goals in the UNFCCC, because it explicitly stipulates safeguards for biodiversity. In particular, treatment of the land-use sector under the 2015 Paris Agreement raises two major concerns. First, the climate convention lacks sufficient safeguards for biodiversity and should move towards greater recognition of governance, biodiversity conservation and a rights-based approach as fundamental enabling conditions (Korwin et al. 2015, Rockström et al. 2021). For example, several land-based measures that have been promoted in the name of climate mitigation can have very large negative impacts on biodiversity if poorly planned, poorly implemented or deployed at too large scales (Pörtner et al. 2021, Smith et al. 2022, Appendix – Figure 5, and see previous and following sections). Second, a carbon sequestration target supported by ecosystem-based solutions is only effective in mitigating climate change when accompanied by full emission reductions in all sectors of the economy, as the ability of natural systems to sequester carbon permanently is undermined by additional emissions (Pörtner et al. 2021, Smith et al. 2022). To meet the Paris Agreement target of warming below 2°C, the vast majority of mitigation efforts must come from swift and ambitious reductions in fossil fuel emissions (Pörtner et al. 2021, Smith et al. 2022, IPCC 2022b).

The wording of Target 8 in the first draft of the GBF includes a contribution of ecosystem-based approaches of at least 10 GtCO$_2$e per year to global mitigation efforts (see also Appendix – Figure 2). This is a very ambitious target, corresponding to approximately one half of the total amount of carbon dioxide currently absorbed by natural systems on land and at sea, and comprising one fifth of the annual mitigation effort called for by the Paris Agreement, to be achieved through natural solutions. **The most recent scientific evidence is in agreement that ambitious implementation of ecosystem approaches / nature-based solutions can potentially contribute 5 GtCO$_2$e per year to climate mitigation efforts with very ambitious efforts for conservation and restoration, as well as in making production and consumption far more sustainable. This could potentially reach 10 GtCO$_2$e per year with extremely ambitious efforts** (see below, and also Target 10 brief). All of the studies below include the constraints that the ecosystem approaches / nature-based solutions are cost-effective, do not compromise food security, and have strong safeguards for biodiversity. Most of these measures have benefits for biodiversity. **An important caveat is that these solutions are sensitive to climate change: failure to greatly reduce emissions from all sectors including energy, transport and agriculture will increase climate risks for natural systems and greatly limit their contributions to mitigation and could potentially turn them into a source rather than a sink for carbon** (Pörtner et al. 2021).

- IPCC (2022b) – "The projected economic mitigation potential of AFOLU {Agriculture, Forestry and Other Land Use} options between 2020 and 2050, at costs below USD100 tCO$_2$-eq^{-1}, is 8-14 GtCO$_2$-eq yr^{-1} (high confidence). 30-50% of this potential is available at less than USD20/tCO$_2$e and could be upscaled in the near term across most regions (high confidence). The largest share of this economic potential [4.2-7.4 GtCO$_2$e yr^{-1}] comes from the conservation, improved management, and restoration of forests and other ecosystems (coastal wetlands, peatlands, savannas and grasslands), with reduced deforestation in tropical regions having the highest total mitigation."

- Girardin et al. (2021) – "Solutions that avoid emissions ramp up quickly — by 2025 — and absorb carbon while avoiding emissions at a rate of 10 gigatonnes of CO$_2$ {equivalent} per year (Gt CO$_2$ yr^{-1})" (See Appendix – Figure 4). This scenario includes the constraints that it is cost-effective; ensures adequate global production of food and wood-based products; involves sufficient biodiversity conservation; and respects land-tenure rights.

- United Nations Environment Programme and International Union for Conservation of Nature (2021) – "A cautious interpretation of the existing evidence, taking account of associated uncertainties and the time needed to deploy safeguards, indicates that by 2030, nature-based solutions implemented across all ecosystems can deliver emission reductions and removals of at least 5 GtCO$_2$e per year, of a maximum estimate of 11.7 GtCO$_2$e per year. By 2050, this rises to at least 10 GtCO2e per year, of a maximum estimate of 18 GtCO2e per year." Based on the analysis of Griscolm et al. (2017), Roe et al. (2021), Girardin et al. (2021, see above), McKinsey (2021) and Wilkinson (2020).

- Pörtner et al. (2021) and Smith et al. (2022) – A wide range of nature-based solutions have large climate mitigation and adaptation potential and include benefits for biodiversity. These are summarized in Appendix – Figure 5. Fully implemented across ocean and land systems including both natural and managed ecosystems, the combined mitigation potential of these measures is greater than 5 GtCO$_2$e per year.

- Strassburg et al. (2020) – "We find that restoring 15% of converted lands in priority areas could avoid 60% of expected extinctions while sequestering 299 gigatonnes of CO_2—30% of the total CO_2 increase in the atmosphere since the Industrial Revolution." This level of restoration of converted land by 2050 is roughly what is needed to achieve Goal A and is equivalent to 10.8 $GtCO_2e$ per year between 2023 and 2050.

Achieving the ambitious mitigation potentials from NbS will require transformative changes that are very similar to those required to achieve the ambitious net gains in ecosystem integrity and area in Goal A, as well as a wide range of other Sustainable Development Goals (Soergel et al. 2021, Leadley et al. 2022). Deep, systemic changes in production and consumption will be needed in addition to strong protection and restoration measures, especially to achieve the higher end of the NbS potential. These changes include large reductions in food loss and food waste, rapid shifts towards more sustainable diets and sustainable intensification of agriculture, especially in those areas with large yield gaps (Appendix – Figure 5, Leadley et al. 2022).

➢ ***Mitigation and adaptation efforts avoid negative impacts on biodiversity***

Both adaptation and mitigation interventions may, if poorly planned and/or implemented, negatively impact biodiversity - and they can, for example, have significantly different impacts on biodiversity depending on the type of intervention. For example, in the case of adaptation, the development of Urban Green Spaces is likely to have very different implications for biodiversity as opposed to engineering solutions such as flood mitigation infrastructure (Pörtner et al. 2021). It is thus essential to understand different categories or typologies of such measures, as well as their implications for biodiversity if designed and/or implemented in a particular way (for example, Table 4.1 from Pörtner et al. 2021 shows different risks and opportunities associated with particular adaptation interventions - including the role of financial incentives and disincentives). Further, in the case of both adaptation and mitigation measures, such interventions should not negatively impact human well-being – issues of social equity and justice are paramount; and the emphasis should be on avoiding creating winners or losers with such measures (for example, expansion of protected areas as an adaptive measure for conservation that dispossesses a local community of either land, or access to key ecosystem services of such land) (Lunstrum 2015, Pörtner et al. 2021).

The three points outlined in the first section of this brief are critical to ensure that solutions are fully based on locally relevant ecosystem criteria, and, further, that secondary or cascading impacts are not negative for either natural systems or for people. For example, commercial non-native forestry to maximize wood growth and carbon capture may (if neither planned nor implemented properly) be detrimental to native biodiversity, change natural dynamics catastrophically (e.g., fires) and/or may cease to support native biota used in food, medicines and cultural practices – thus cannot be considered a 'nature-based solution' under this Target.

Actions must be 'future-proofed' and forward-looking, to consider their function and viability in future decades (e.g., in 20, 30, and even 50 years) – climate migration, changing natural processes (e.g., rainfall, fire regimes, ocean currents, etc.) should be considered, amongst other potentially confounding factors (Liz et al. 2022; Pörtner et al. 2021; van Kerkhoff et al. 2019).

➢ **Linkages to other targets**

Target 8 has direct co-benefits and interactions in 14 out of the 21 action targets of the GBF, notwithstanding a range of indirect links (see below). Examples include:

Target 10 – increase in production land and sea-scapes has been facilitated by fossil fuel-based energy that clear-cuts forests and trawls, dredges and mines the seabed. Managing all production scapes for sustainability, preventing further habitat loss and halting damaging methods will immediately reduce greenhouse gas emissions (as well as a range of other co-benefits).

Target 18 - the removal of financial subsidies to fossil fuels, commercial agriculture and commercial fisheries, among other sectors, would reduce fossil fuel emissions, and in some cases such as fishing, reduce pressure and help restore fisheries, supporting mitigation and adaptation.

Indicators for a range of targets indirectly contribute to Target 8 (for example, T1, T2 and T3, implemented with an eye to multiple benefits, could both support biodiversity conservation and benefits in response to climate (adaptation and/or mitigation). However, to maximize the contribution that actions under these targets make to "minimizing the impact of climate change on biodiversity", a stronger emphasis needs to be placed on indicators which explicitly account for the impact that resulting changes in the area, connectivity and integrity of natural ecosystems are expected to have on the capacity of landscapes and seascapes to retain biodiversity in the face of climate change (see Indicators section below).

3) Indicators

- ***Indicators in GBF monitoring framework***

Headline in bold, component indicators in plain and *complementary indicators in italics (pre-SBSTTA 24)*

8.0.1 National [net] green-house[emissions] [gas inventories] from land use and land use change [by land use and land use change category, subcategory, [and]natural/modified]

8.1.1 Number of countries with NDCs, long-term strategies, national adaptation plans and adaptation communications that reflect biodiversity (based on information from UNFCCC and SDG 13.2.1)

8.2.1. Total climate regulation services provided by ecosystems by ecosystem type (System of Environmental Economic Accounts)

8.3.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030 which include biodiversity (based on SDG 13.2.1)

t8.1. Above-ground biomass stock in forest (tonnes/ha)

t8.2. Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030 (SDG indicator 13.1.2)

t8.3. Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies (SDG indicator 13.1.3)

t8.4. Number of least developed countries and small island developing States with NDCs, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications (SDG indicator 13.b.1)

- ***Comments on indicators and possible additional indicators***

None of the indicators listed for Target 8 in the draft monitoring framework explicitly addresses the extent to which actions enhancing the area, connectivity and integrity of natural ecosystems will "minimize the impact of climate change on biodiversity". Conversely, this critically important relationship is currently addressed by only one of the many indicators listed for Goal A and Targets 1, 2 and 3—i.e., the Bioclimatic Ecosystem Resilience Index (BERI; Ferrier et al. 2020), listed as a complementary indicator for Goal A and Target 2. At the recent SBSTTA sessions in Geneva, a proposal was made to also include the BERI as a headline indicator for Target 8 (Appendix 2 of CBD/SBSTTA/REC/24/2) which would go a long way towards filling this gap, at least for terrestrial systems.

4) Linkages to other relevant international agreements, bodies and monitoring efforts

Those policies and monitoring efforts described here are selected as those with the most immediate relevant linkages. They are by no means exhaustive, and are all international in scale. Strong recognition also needs to be given to interventions at local, national and regional scales where climate-biodiversity multiple benefits are realized through innovative design and proper implementation.

The international measures include the journey from the 2015 Paris Agreement to the 2021 Glasgow COP; where the latter effectively had the aim of making the Paris Agreement fully operational. More specifically, the 2021 Glasgow Climate Pact, amongst other measures, strengthened efforts to build resilience to climate change, to curb greenhouse gas emissions, and (in theory) to provide the necessary finance for both. As well as an effective statement of renewed commitment, Glasgow laid the ground for a collective agreement to reduce the gap between existing emission reduction plans and what is required to reduce emissions, to limit to 1.5 degrees. Glasgow effectively served as the first concrete call in this arena to phase out both coal power and inefficient subsidies for fossil fuels (received with some reluctance on the part of some member states). Finally, and critically for the GBF process and the focus of this brief, it constituted the first clear recognition of the role of nature in climate mitigation and adaptation (driven in part by IPCC-IPBES report, Pörtner et al. 2021).

Additional relevant international agreements include: i) the Strategic Plan for Biodiversity 2011-2020 and ongoing preparation for the post-2020 global biodiversity framework is of critical importance here – this brief effectively forms part of this process, ii) the Sendai Framework for Disaster Risk Reduction is integrated into targets and indicators (see t8.2 & 8.3.1) and iii), the 2030 Agenda for Sustainable Development, links to both component and complementary indicators, amongst others (see section on Linkages to Other Targets above).

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TARGET 8—CLIMATE OBJECTIVES – APPENDIX

Figure 1: Examples of future projected impacts of climate change and CO_2 on biodiversity and ecosystem processes (Source: Arneth *et al.* 2020; reproduced with permission of the authors)

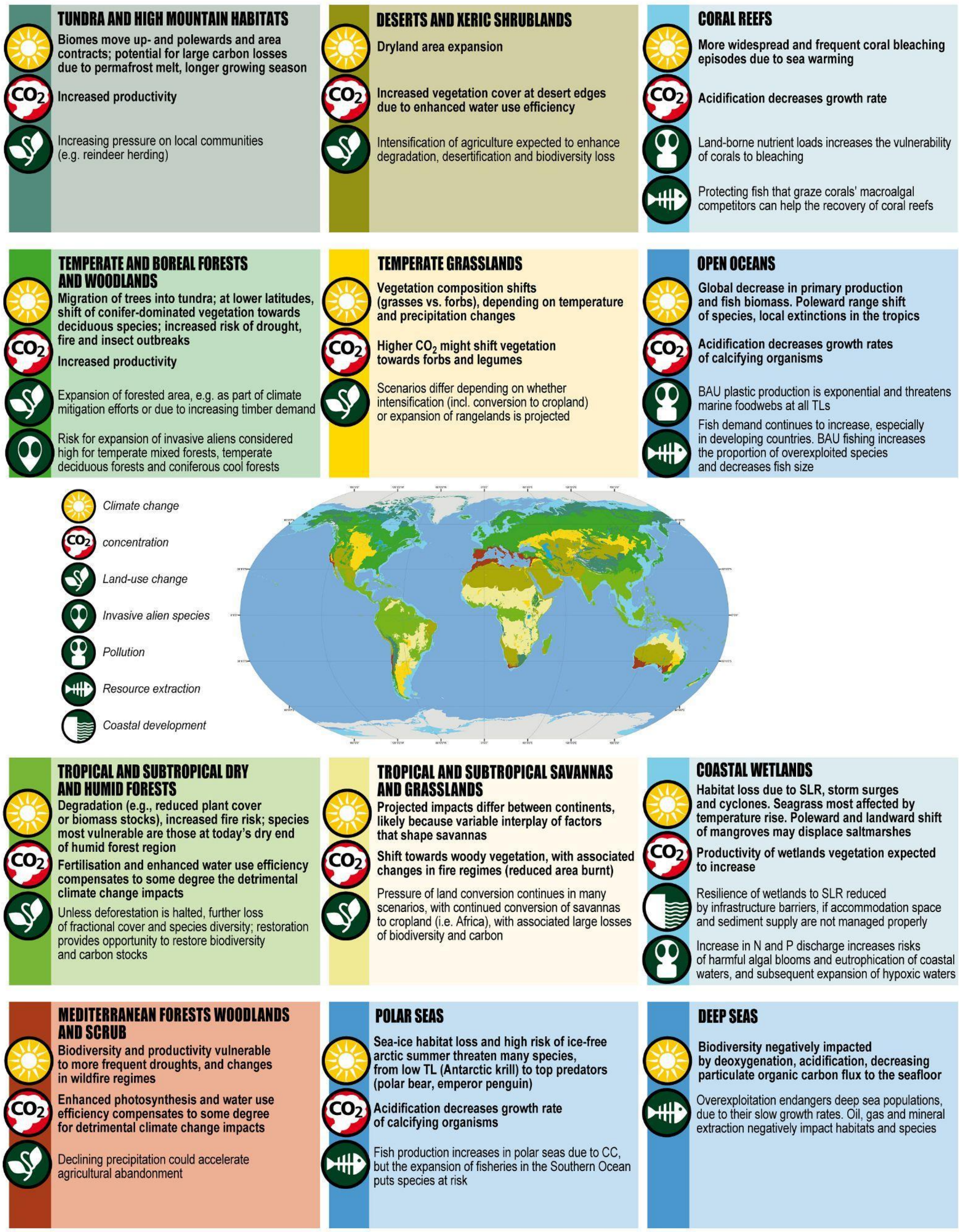

Figure 2: "Nature-based solutions" aid adaptation to, and mitigate against the effects of, climate change while restoring and protecting biodiversity. (Source: E. Archer, pers. communication)

Nature-based solutions

<table>
<tr><th>Actions</th><th>Terrestrial</th><th>Freshwater</th><th>Marine</th></tr>
<tr><td rowspan="2">Protect biodiversity</td><td>Protect native forests, bush, and grasslands</td><td>Stop pollution and sedimentation into streams, rivers, ponds, lakes.</td><td>Ban seabed trawling and dredging</td></tr>
<tr><td colspan="3">Control introduction and spread of invasive species and pests</td></tr>
<tr><td rowspan="2">Reconnect habitats and populations</td><td colspan="2">Use riverbank and hedgerow corridors to connect protected native habitats</td><td>Restrict fragmentation of habitats by coastal development and seabed trawling and dredging</td></tr>
<tr><td colspan="3">Reduce habitat and species loss outside protected areas to add species dispersal (corridors)</td></tr>
<tr><td>Living with nature</td><td colspan="2">Environmentally sustainable agriculture, tourism, and other land and freshwater uses</td><td>Environmentally sustainable aquaculture, fisheries, tourism,</td></tr>
<tr><td>Restoration and recovery</td><td>Rehabilitate old mines, quarries and industrial lands</td><td>Stabilise riverbanks. Remove weirs and artificial barriers to fish migration.</td><td rowspan="2">Ban removal marine life and habitat fishing in selected areas to allow passive recovery of habitats, natural population structure, and food webs</td></tr>
<tr><td>Rewilding</td><td colspan="2">Reintroduce extirpated native species</td></tr>
<tr><td>Reduce erosion, soil loss,</td><td colspan="2">Plant forests and controlling grazing to enable uplands to absorb rainfall and reduce flash-floods</td><td>Protect sand-dune systems from erosion due to human and farm animal trampling.</td></tr>
<tr><td>Control flooding</td><td colspan="3">. Set aside land for saltmarshes and mangroves to buffer against river and seawater flooding.
Link estuarine and upriver protected areas to provide more wildlife habitat and absorb storm surges and floods.</td></tr>
<tr><td>Urban development</td><td>Concentrate development to more cost efficiently manage transport and waste management infrastructure</td><td>Limit upland development to protect freshwater quality.</td><td>Ban construction in areas at risk of sea level rise and associated storm surges.</td></tr>
<tr><td rowspan="2">Greenhouse gas mitigation</td><td>Reforestation (especially mangroves); Revegetation; Fewer farm mammals</td><td>Repair and expand wetlands to capture and deposit carbon in soils.</td><td>Limit seabed disturbance by trawling and dredging that releases CO_2 and CH_4. Eliminate harmful fishery subsidies.</td></tr>
<tr><td colspan="3">Reduce use of fossil fuels and reapply subsidies to renewable energy sources.</td></tr>
<tr><td rowspan="2">Carbon sequestration</td><td colspan="3">Allow biodiversity to flourish and capture CO_2 from the air and sequester it in biomass, soils and sediments.</td></tr>
<tr><td>Manage forestry to maximise in situ food web biomass.</td><td colspan="2">Rebuild fisheries to maximise in situ food web biomass.</td></tr>
<tr><td>Social</td><td colspan="3">Communicate information on the benefits of adaptation measures to the public</td></tr>
<tr><td>Political and economic</td><td colspan="3">Provide leadership and governance of mitigation and adaptation measures, including through regulations and economic incentives that guide the transition to a low carbon emission economy</td></tr>
<tr><td rowspan="2">Scientific</td><td colspan="3">Rapidly release and explain monitoring data to society so that the public and policy makers are informed of trends in biodiversity and related factors, including climate variables, extreme weather-related events, threatened and invasive species, natural habitats, and their relationships.</td></tr>
<tr><td colspan="3">Conduct research to improve understanding of cause-effect relationships regarding environmental factors and biodiversity trends, including in nature conservation, forestry, agriculture, fisheries, and food production sectors, and improve projections of consequences of management action and inaction.</td></tr>
</table>

Figure 3. Co-benefits of biodiversity protection and restoration for climate mitigation (Source: Shin et al. 2022; Pörtner et al. 2021).

	Post-2020 Action targets for 2030		Biodiversity measures (& corresponding sections in the main text)	Climate change mitigation
Reducing threats to biodiversity	T1	Biodiversity-inclusive spatial planning addressing land/sea use change, retaining intact & wilderness areas	Avoiding deforestation (2.1)	+
			Avoiding degradation of permafrost areas (2.1)	+
	T2	Restoration of at least 20% of degraded ecosystems, ensured connectivity & focus on priority areas	Reforestation, avoiding forests degradation (2.1)	+
			Coastal restoration (2.1)	+
			Restoring degraded semi-arid ecosystems (2.1)	?
			Restoring inland wetlands (2.1)	?
			Biodiversity offsets (2.1)	+
	T3	Well connected & effective system of protected areas, at least 30% of the planet	Expanding networks of protected areas & corridors (2.2)	++
	T4	Recovery & conservation of species of fauna & flora	Rewilding with large terrestrial mammals (2.3)	?
			Rebuilding marine megafauna (2.3)	+
	T5	Sustainable, legal & safe harvesting, trade & use of wild species	Sustainable fishing (2.4)	+
	T6	Prevention & reduced rate of introductions, control or eradication of invasive alien species		
	T7	Reduced pollution from all sources, including excess nutrients, pesticides, plastic waste	Reducing pollution from excess nutrients (2.5)	+
	T8	Impacts of climate change on biodiversity minimized, contributions to climate change mitigation, adaptation		++
Meeting people's needs	T9	Ensured benefits, incl. food security, medicines, & livelihoods, through sustainable management of wild species	Sustainable harvesting of wild species (2.4)	+
	T10	All areas under agriculture, aquaculture & forestry are managed sustainably, through biodiversity conservation & sustainable use & increased productivity & resilience	Biodiversity-friendly agricultural systems (2.6)	+
			Intensive vs less intensive agriculture (2.6)	+
			Combatting woody plant encroachment (2.6)	?
	T11	Contribution to regulation of air quality, hazards & extreme events & quality & quantity of water	(2)	?
	T12	Increased area of, access to, & benefits from green/blue spaces for health & well-being in urban areas	Increasing benefits from biodiversity & green/blue spaces in urban areas (2.7)	+
	T13	Ensured access to & the fair & equitable sharing of benefits from genetic resources & traditional knowledge		
Tools & solutions	T14	Biodiversity values integrated into policies, regulations, planning, development, poverty reduction, accounts & assessments	Mainstreaming biodiversity (2.8)	+
	T15	Dependencies & impacts on biodiversity assessed in all businesses, negative impacts halved	Sustainable food production & supply chains (2.4)	+
	T16	People are informed & enabled to make responsible choices, to halve the waste & reduce overconsumption where relevant	Sustainable consumption patterns (2.9)	+
	T17	Preventing, managing or controlling potential adverse impacts of biotechnology on biodiversity & human health		
	T18	Redirect, repurpose, reform or eliminate incentives harmful for biodiversity in a just & equitable way	Eliminating incentives harmful for biodiversity (2.10)	+
	T19	Increasing financial resources & flows to developing countries, ensured capacity-building, technology transfer & science cooperation		?
	T20	Relevant knowledge, incl. ILK, guides the management of biodiversity by promoting awareness, education & research		
	T21	Equitable & effective participation in decision-making by IPLCs, respecting their rights over lands, territories & resources		

Contribution to climate change mitigation

- Significantly positive, strong scientific evidence
- Potentially positive, incomplete evidence & quantification
- Unresolved, lack of evidence, system-dependent, tradeoffs
- Indirect positive
- Loose or non-existent link
- Negative, strong scientific evidence

Reliability of the mitigation outcome

- ++ High
- \+ Medium
- ? Unresolved, lack of evidence

Figure 4. Potential global mitigation potential (avoided emissions and sequestration) from nature-based solutions (Source: Girardin et al. 2021)

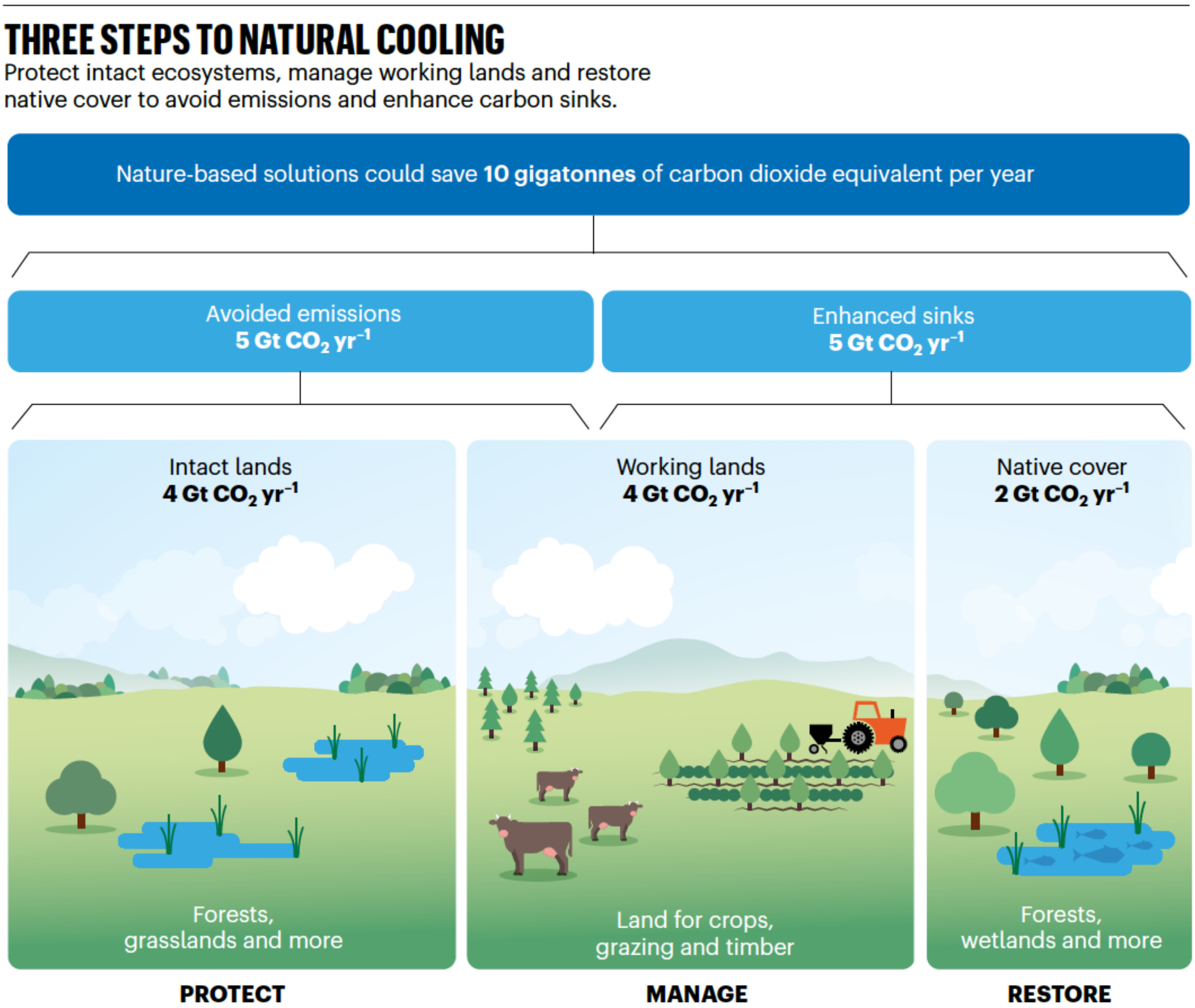

Figure 5. Estimates of climate mitigation potential and biodiversity co-benefits or trade-offs of a wide range of ocean- and land-based mitigation options. (Source: Smith et al. 2022).

Practice	Mitigation potential	Adaptation potential (estimated number of people more resilient to climate change from intervention)	Biodiversity impact (positive unless otherwise stated)	Summary/synopsis of overall expected impact
(a) Ocean				
Carbon storage in seabed	0.5–2.0 Gt CO_2e yr^{-1}	No global estimates	Low	
Costal and marine ecosystems	0.5-1.38 Gt CO_2e yr^{-1}	No global estimates	Medium/High	
Fisheries, aquaculture and dietary shifts	0.48–1.24 Gt CO_2e yr^{-1}	No global estimates	Medium/High	
Ocean-based renewable energy	0.76–5.4 Gt CO_2e yr^{-1}	No global estimates	Low	
(b) Land				
Increased food productivity	>13 Gt CO_2e yr^{-1}	>163 million people	High[1]or Low[2]	
Improved cropland management	1.4–2.3 Gt CO_2e yr^{-1}	>25 million people	Medium	
Improved grazing land management	1.4–1.8 Gt CO_2e yr^{-1}	1–25 million people	Medium	
Improved livestock management	0.2–2.4 Gt CO_2e yr^{-1}	1–25 million people	Medium	
Agroforestry	0.1–5.7 Gt $C_2$2e yr^{-1}	2300 million people	High	
Agricultural diversification	> 0	>25 million people	High	
Reduced grassland conversion to cropland	0.03–0.7 Gt CO_2e yr^{-1}	No global estimates	High[3]	
Integrated water management	0.1–0.72 Gt CO_2e yr^{-1}	250 million people	Medium	
Improved and sustainable forest management	0.4–2.1 Gt CO_2e yr^{-1}	> 25 million people	High	
Reduced deforestation and degradation	0.4–5.8 Gt CO_2e yr^{-1}	1–25 million people	High	
Reforestation and forest restoration	1.5–10.1 Gt CO_2e yr^{-1}	>25 million people	High	
Afforestation	See Reforestation	No global estimates	Negative/low positive[4]	
Increased soil organic carbon content	0.4–8.6 Gt CO_2e yr^{-1}	Up to 3200 million people	Medium	
Reduced soil erosion	Source of 1.36–3.67 to sink of 0.44–3.67 Gt CO_2e yr^{-1}	Up to 3200 million people	Low	
Biochar addition to soil	0.03–6.6 Gt CO_2e yr^{-1}	Up to 3200 million people; but potential negative (unquantified) impacts if arable land used for feedstock production	Low[5]	
Fire management	0.48–8.1 Gt CO_2e yr^{-1}	> 5.8 million people affected by wildfire; max. 0.5 million deaths per year by smoke	Low	
Management of invasive species / encroachment	No global estimates	No global estimates	High	
Restoration and reduced conversion of coastal wetlands	0.3–3.1 Gt CO_2e yr^{-1}	up to 93–310 million people	High	

Restoration and reduced conversion of peatlands	0.6–2.0 Gt CCO_2e yr^{-1}	No global estimates	High			
Biodiversity conservation	0.9 Gt CO_2e-e yr^{-1}	Likely many millions	High			
Enhanced weathering of minerals	0.5–4.0 Gt CO_2e yr^{-1}	No global estimates	Insufficient data to make judgement			
Bioenergy and BECCS	0.4–11.3 Gt CO_2e yr^{-1}	Potentially large negative consequences from competition for arable land and water.	Negative/low positive[4]			
On-shore wind	Depends on what energy source is substituted	No global estimates	Low			
Solar panels on land	Depends on what energy source is substituted[6]					
(c) Demand changes (related to land)						
Dietary change	0.7–8.0 Gt CO_2e yr^{-1} (land)	No global estimates	High[7]			
Reduced post-harvest losses	4.5 Gt CO_2e yr^{-1}	320–400 million people	Medium/High			
Reduced food waste (consumer or retailer)	0.8–4.5 Gt CO_2e yr^{-1}	No global estimates	Medium/High			
Management of supply chains	No global estimates	>100 million	Medium[8]			
Enhanced urban food systems	No global estimates	No global estimates	Medium			

 Mitigation potential  Adaptation potential  Possible adaptation potential  Negative impacts on biodiversity  Positive impacts on biodiversity

1. If achieved through sustainable intensification;
2. If achieved through increased agricultural inputs;
3. If conversion takes place in (semi-)natural grassland;
4. If small spatial scale and (for bioenergy) second generation bioenergy crops;
5. Low if biochar is sourced from forest ecosystems, application can be beneficial to soils locally;
6. See Creutzig et al. (2017) for a recent summary of energy potentials;
7. Due to land sparing;
8. Related to increased eco-labelling, which drives consumer purchases towards more ecosystem-friendly foods.