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THE POST-2020 GLOBAL
BIODIVERSITY FRAMEWORK
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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. 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 six 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 four briefs on individual targets, 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 (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 the 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 Díaz 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 four targets or two specific parts of the GBF.

This focus on only four 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

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[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).

A collection of the key messages from all the briefs can be found below.

Stand-alone versions of each of the science briefs are also available on the GEO-BON web site: https://geobon.org/science-briefs/

Target briefs

Targets analysed:

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

Ecosystem area and integrity brief - Starts on page 64 of the present document

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 :

- Background
- Overview
- Quantitative and qualitative analysis of ecosystem area objectives
- Glossary
- References
- Background and Glossary Appendices

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 be accompanied by a glossary with suggestions for annotations and additions to the GBF glossary.

The brief on the GBF monitoring framework has been published as an information document for the technical meeting held in Bonn, 29 June to 1 July, 2022 (CBD/ID/OM/2022/1/INF/2).

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

COLLATED KEY MESSAGES

TARGET 3 - Area-based conservation measures of protected areas (PAs) and Other Effective Conservation Measures (OECM)

Target 3 is focused on the area-based conservation measures of protected areas (PAs) and Other Effective Conservation Measures (OECM) as defined by the CBD and must focus on both quality and quantity elements. Limited kinds of sustainable use, in many cases in relation to customary use and the rights and tenure of Indigenous Peoples and Local Communities (IPLCs), are permitted in some IUCN Protected Area categories and under OECM guidance. Large scale, intensive and/or industrial exploitation (in agriculture, fishing and forestry) that are managed sustainably with biodiversity conservation outcomes are not compatible with Target 3 and are covered under Targets 5, 9 and 10.

Quantity:

- The target level ***"at least 30%"*** is well supported in the scientific literature as the lower limit for effective biodiversity conservation. PAs and OECMs are intended to protect a range of biodiversity values (e.g., species and ecosystems at risk, representativity, ecological viability, geographically restricted species, in-site carbon, etc.), and the greater the inclusion of multiple values, the higher the proportion that needs to be protected.
- There are concerns that a focus on the 30% area target, as occurred with achieving the area-based target of Aichi Target 11, will detract from the quality elements of target 3. Substantial increases in resources, capacity and international collaboration will be critical to ensure that the quality elements of this target are met.

Quality elements:

The Quality elements in Target 3 focus on several distinct elements, which are at least as important as the quantity element for achieving the objectives of this target:

- ***Areas of importance for biodiversity***—It is possible to be far more efficient and effective in avoiding biodiversity loss by selecting those areas important for conservation, such as Key Biodiversity Areas.
- … ***and its contributions to people***—the importance of nature's contributions to people, which always result from biodiversity, emphasises the importance of many PAs and OECMs for ecosystem services, including for Indigenous Peoples and Local Communities. These considerations induce significant trade-offs for spatial optimization with solely a biodiversity focus.
- ***Effectively managed***—successful biodiversity outcomes at the site level require effective management, often lacking in the current system of PAs and OECMs.
- ***Equitably governed***—protected areas require social licence provided by a shared voice in decision-making and equitable benefit sharing, and free, prior and informed consent (FPIC).
- ***Biodiversity representative***— PAs and OECMs should be designed so that the full ranges of biodiversity, including genes, species, and ecosystems, have some level of area-based conservation.
- ***Well-connected*** and ***integrated into wider landscapes and seascapes***—biological connectivity and wider land, sea and freshwater scape integration are essential for the integrity of the sites.

National contributions – While there is an expectation for all countries to contribute to global targets, all countries might not be able to protect 30% of their lands and seas in protected areas and OECMs. Thus, some countries might need to protect more than 30%, to protect areas with globally significant biodiversity importance. Coordinated spatial planning across countries is essential to assure the global target is met jointly.

TARGET 7 - Nutrient and pesticide pollution

- 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 losses 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 pesticide risk 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.

TARGET 8 - Climate Change

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.

TARGET 10 - Sustainable agriculture

- Sustainable management and use of terrestrial and aquatic food production systems are key to reducing pressures on biodiversity and preventing the transgression of planetary boundaries.
- Between 18 to 33% of agricultural lands currently have insufficient biodiversity: this degrades ecosystem functions, creates unacceptable risk for food security, and compromises the resilience and sustainability sought in Target 10.

Sustainability:

- The approach to sustainability across various production systems needs clarity on its operationalization by including metrics to analyse and monitor the i) change in biodiversity, ii) production of nature's contribution to people (NCP), iii) interlinkages between biodiversity and production, iv) relationships between biodiversity and demand-side factors, and v) diversification strategies within land uses, between land uses and across landscapes or basins. The GBF would profit from greater clarity on this in the wording of Target 10 and in the choice of indicators for this target.

Sustainable Production:

- Sustainable production includes many management approaches that can make agriculture sustainable such as: i) diversifying production systems, ii) making use of locally adapted and nutritious crop species and varieties, iii) ensuring water use is within the limits needed to maintain environmental flows and iv) maintaining complexity by embedding natural habitat in agricultural landscapes. The GBF, perhaps in the glossary, would benefit from clarification of sustainable agriculture practices.

- Greater integration of biodiversity, including dietary diversity, in sustainable production is necessary for improving health, eliminating hunger and achieving nature-positive outcomes.

- Enhancing crop diversity in production systems and landscapes to produce more diverse foods can be a win-win solution for both improved nutrition and biodiversity.

- Regenerative agricultural practices can generate additional critical ecosystem services by maintaining biodiversity in and around agricultural lands, which when implemented at scale, offer potential benefits including but not limited to carbon sequestration, habitats and connectivity for biodiversity including pollinating and pest regulating species.

- Innovation and investment in productive and sustainable production can address trade-offs and close both yield and NCP production gaps.

- Investment is needed to close the production gap of crops contributing to healthy diets, in line with Sustainable Development Goals (SDGs) 2 and 3, including urgent investments in undervalued and underproduced agrobiodiversity vital to dietary health.

Policies:

- Agriculture and biodiversity need to be more strongly integrated into global policies, practices and other public sector instruments across all sectors of government. These public sector instruments should be guided by science-based targets and true cost accounting to incentivize transitions to sustainable agriculture, recognizing producers (e.g., farmers) as producers of both material goods and of environmental benefits and to make healthy food affordable and available.

- More investment is needed to build the capacity of scientists, policy officials and institutions in the Global South, filling the knowledge gaps on agricultural systems.

- Sustainability in trade can be supported through direct investment in agriculture producing countries to support them in complying with the standards, due diligence requirements, tracing mechanisms, enforcement and border tariffs to reduce adverse impacts of consumption patterns on ecosystems and biodiversity.

- The aspects advanced through Target 10 help deliver several of the other targets of the GBF as well as the SDGs, especially SDG 2, 3, 12, 13 and 15.

Ecosystem Area and Integrity Objectives of The Post-2020 Global Biodiversity Framework

- Achieving net gains in the integrity of all ecosystems and in the area and integrity of natural ecosystems by 2030 and 2050 depends on concerted actions across all targets, and requires transformative change including considerable strengthening of conservation measures, systemic changes to increase the sustainability of production and consumption, and mobilisation of all sectors of society.
- "No net loss" and "net gain" policies for nature have generally been successful only when they set clear limits on losses, and have clear objectives for restoration such as strict like-for-like compensation of losses. Spatial planning and area-based conservation are critical elements of the GBF, but could be worded in a way that provides clearer objectives for reducing losses that build on Aichi Target 5. Similarly, the restoration target could include clearer qualitative and quantitative objectives for contributions to ecosystem area and integrity.
- Net gains in the area of natural ecosystems occur when the restoration of transformed to natural ecosystems is greater than losses of natural ecosystems. For example, net gains of 5% in the global area of natural terrestrial ecosystems by 2030 could be achieved with greatly reduced rates of loss of natural ecosystems and very ambitious restoration of transformed to natural ecosystems on the order of 350-400 Mha over the period 2021-2030. Global scale scenarios and other evidence indicate these reductions in losses and increases through restoration to achieve a 5% net gain in the <u>area</u> of natural terrestrial ecosystems are very ambitious but feasible.
- There is potential for quickly slowing and in some cases reversing losses the integrity of existing natural and managed ecosystems by reducing pressures leading to degradation. Gains in integrity can also be achieved through widespread restoration and rehabilitation actions. However, continued losses of natural ecosystems will have large negative impacts on ecosystem integrity; and some direct drivers of degradation, such as climate change, will inevitably intensify over the coming decade. In addition, newly created natural areas will have low integrity at first, and may take decades or even centuries to reach high integrity and so will make only modest contributions to integrity before 2030. The feasibility of net gains in ecosystem integrity is more difficult to evaluate than for the area of natural ecosystems, but several lines of evidence suggest that a 5% net increase in the <u>integrity</u> of natural terrestrial ecosystems by 2030 is near the upper limit of what is feasible.
- Directly translating global objectives, especially quantitative objectives, to national and local levels will likely result in sub-optimal use of resources and outcomes for biodiversity, as well as setting levels of ambition that are too low in some areas, and unrealistically high in others. Translation to national and local levels is more likely to succeed if it is developed inclusively with all actors, in particular indigenous peoples and local communities, considers past and present states and drivers of biodiversity, is resourced adequately, and incorporates strong, transparent governance. One way of assessing implementation and progress towards global goals would be to develop plans that take into account national contexts, conduct regular review of collective national contributions to global goals and then revisit national plans if needed. To facilitate this, indicators should be scalable so that national ambitions and contributions can be summed to assess their collective contributions and appropriate burden-sharing.
- One of the biggest challenges of the GBF is to meet objectives for biodiversity conservation and sustainable use at the same time, and ecosystem objectives are at the heart of this challenge. Spatial planning can play a major role in helping to reconcile these objectives and in finding synergies, and this could be more clearly reflected in the wording of Target 1.
- Clear definitions and consistent wording across goals and targets is essential for the implementation, monitoring and coherence of the GBF: this is lacking in the current draft. This brief provides advice on definitions and relatively modest changes in wording that would help clarify the levels of ambition, translation to national levels and overall coherence of the GBF.

TARGET 3: PROTECTED AND CONSERVED AREAS

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 incorporates the area-based Targets 1, 2, 3 and 10.

This science brief addresses the area and quality of protection and conservation under Target 3

The analysis focuses on the wording of the quantitative and qualitative elements of target 3, 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 3. Ensure that at least 30 per cent globally of land areas and of sea areas, especially areas of particular importance for biodiversity and its contributions to people, are conserved through effectively and equitably managed, ecologically representative, and well-connected systems of protected areas and other effective area-based conservation measures and integrated into the wider landscapes and seascapes.***

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) References

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KEY MESSAGES CONCERNING THE WORDING, QUANTITY AND QUALITY OBJECTIVES OF TARGET 3

Target 3 is focused on the area-based conservation measures of protected areas (PAs) and Other Effective Conservation Measures (OECM) as defined by the CBD and must focus on both quality and quantity elements. Limited kinds of sustainable use, in many cases in relation to customary use and the rights and tenure of Indigenous Peoples and Local Communities (IPLCs), are permitted in some IUCN Protected Area categories and under OECM guidance. Large scale, intensive and/or industrial exploitation (in agriculture, fishing and forestry) that are managed sustainably with biodiversity conservation outcomes are not compatible with Target 3 and are covered under Targets 5, 9 and 10.

Quantity:

- The target level ***"at least 30%"*** is well supported in the scientific literature as the lower limit for effective biodiversity conservation. PAs and OECMs are intended to protect a range of biodiversity values (e.g., species and ecosystems at risk, representativity, ecological viability, geographically restricted species, in-site carbon, etc.), and the greater the inclusion of multiple values, the higher the proportion that needs to be protected.
- There are concerns that a focus on the 30% area target, as occurred with achieving the area-based target of Aichi Target 11, will detract from the quality elements of target 3. Substantial increases in resources, capacity and international collaboration will be critical to ensure that the quality elements of this target are met.

Quality elements:

The Quality elements in Target 3 focus on several distinct elements, which are at least as important as the quantity element for achieving the objectives of this target:

- ***Areas of importance for biodiversity***—It is possible to be far more efficient and effective in avoiding biodiversity loss by selecting those areas important for conservation, such as Key Biodiversity Areas.
- … ***and its contributions to people***—the importance of nature's contributions to people, which always result from biodiversity, emphasises the importance of many PAs and OECMs for ecosystem services, including for Indigenous Peoples and Local Communities. These considerations induce significant trade-offs for spatial optimization with solely a biodiversity focus.
- ***Effectively managed***—successful biodiversity outcomes at the site level require effective management, often lacking in the current system of PAs and OECMs.
- ***Equitably governed***—protected areas require social licence provided by a shared voice in decision-making and equitable benefit sharing, and free, prior and informed consent (FPIC).
- ***Biodiversity representative***— PAs and OECMs should be designed so that the full ranges of biodiversity, including genes, species, and ecosystems, have some level of area-based conservation.
- ***Well-connected*** and ***integrated into wider landscapes and seascapes***—biological connectivity and wider land, sea and freshwater scape integration are essential for the integrity of the sites.

National contributions – While there is an expectation for all countries to contribute to global targets, all countries might not be able to protect 30% of their lands and seas in protected areas and OECMs. Thus, some countries might need to protect more than 30%, to protect areas with globally significant biodiversity importance. Coordinated spatial planning across countries is essential to assure the global target is met jointly.

BACKGROUND ON THE WORDING, QUANTITY AND QUALITY OBJECTIVES OF TARGET 3

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

Goal A: Target 3 is focused directly on Goal A; on in-situ, or ecosystem-based, conservation of nature using protected areas (PAs) and other-effective area-based conservation measures (OECMs) as defined under the CBD. Target 3 responds primarily to the direct driver of change in land and sea use (also called habitat loss, degradation and fragmentation), because protected areas and OECMs, by definition, act to prevent them. Land and sea use are the largest direct drivers of biodiversity loss in terrestrial, freshwater and marine ecosystems including direct exploitation (Díaz et al. 2019, O'Hara et al. 2021).

Protected Areas and OECMs also reduce other direct drivers of biodiversity loss, such as harmful direct exploitation (Target 5), pollution (Target 7) originating within or adjacent to them, invasive alien species (Target 6), and by storing and sequestering carbon and providing a measure of resilience to climate change (Target 8).

Goal B: Target 3 contributes significantly to Nature's Contributions to People through PAs and OECMs providing an enormous range of ecological services (e.g., material services such as food, clean water, medicinal plants, and spill-over fishing benefits, and non-material services such as aesthetic inspiration and spiritual health), depending on the uses permitted within or adjacent to them (IPBES, 2019).

Goal C: Protected areas and OECMs provide important species inventories, regulate the access to those species and can ensure benefit sharing following agreed principles established by the CBD.

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

Note that Target 3 is focused only on the area-based conservation measures of protected areas and OECMs as defined by the CBD. Limited kinds of sustainable use are compatible with some IUCN PA categories (Dudley 2008) and are foundations of OECM based on customary use and the rights and tenure of Indigenous Peoples and Local Communities (CBD Decision 14/8, WCPA Task Force on OECMs, 2019). Specifically, the following is advised in the scientific literature, guidance documents and CBD decisions:

Protected Areas: By definition, all protected areas have as the primary objective the conservation of nature, but only categories Ia, Ib, II, III and VI include the requirement that biodiversity (from genes to species to ecosystems) is as close to a natural state as possible. The primary objective of the remaining IUCN categories (IV, V) is to conserve specific species and/or landscapes (Dudley 2008), which represent different management approaches to conserving nature. All categories are important, and all should be managed, first and foremost, for nature conservation.

OECMs: CBD Decision 14/8 defining other-effective area-based conservation measures include a criterion for OECMs that focuses on "associated ecosystem functions and services and cultural, spiritual, socio-economic and other locally relevant values", with two sub-criteria: i) on ecosystem functions and services, and j) on "cultural, spiritual, socio-economic, and other locally relevant values". Biodiversity conservation may not be the primary management objective, but the use and management of any service or value must not negatively impact the value of biodiversity conservation (page 7, WCPA Task Force on OECMs 2019). Supporting the implementation of OECMs (Gurney et al. 2021, Jonas et al. 2021) will be essential for achieving the GBF not only for Target 3, but also Target 21 and Goals A and B, and in support of wildlife and sustainable use targets 5 and 9, respectively.

Commercial, intensive, and large-scale exploitation (in agriculture, fishing, forestry, or other sectors) that are managed sustainably with some biodiversity conservation outcomes are not compatible with Target 3, but are covered under Target 10, on sustainable management of production land and waterscapes (see Target 10 brief). Specific sustainable use outcomes could be covered under Targets 5 and 9.

Target 3 contains several interrelated elements that can be grouped under the headings of quantity (area) and quality, both of which are essential to the achievement of the Target (see also Ecosystem Brief, sections 1b and 1c, respectively):

Quantity: PAs and OECMs are intended to protect a range of biodiversity values—species and ecosystems at risk, representativity, ecological viability, geographically restricted species and ecosystems, species aggregations, climate refugia, high carbon ecosystems, and biological connectivity. The range of values to be protected results in varying proportions of area that should be protected. There is strong scientific support that maintaining a subset of these values (e.g., rare species and representivity) requires the protection of at least 30% of a region, or globally, while maintaining the entire value set listed above results in values up to 70% (reviewed in Woodley et al. 2109). Managing the top-ranked 30% of land areas for biodiversity conservation, will conserve 81% of species (Jung et al. 2021). Similar ranges have been assessed for measures of ocean biodiversity (Zhao et al. 2020).

There is little debate that reaching 30% area coverage of PAs and OECMs would have tremendous benefits for biodiversity if all the quality elements of Target 3 are also met (IPBES 2019). There is, however, concern that focusing solely on the percent area coverage of this target could be at the detriment of achieving the quality elements of the target (Visconti et al. 2019, Pressey et al. 2021, Roessger et al. 2022), as discussed in the quality elements below. There is evidence from observations and models that the failure to achieve these may largely undermine benefits of increased area coverage (Kuempel et al. 2018, Roessger et al. 2022, Leadley et al. 2022).

Concerns also arise around inadequate management and resources, inadequate levels of protection and lack of representativity that includes all elements of biodiversity (Visconti et al. 2019, Shah et al. 2021). Very substantial increases in resources and capacity will therefore be necessary to achieve the objectives of this target (Geldmann et al., 2021, Robson et al. 2021). Ensuring high levels of protection for the 30% area is also critical for success (Shah et al. 2021, Grorud-Colvert et al. 2021). Finally, ecological connectivity is often a transboundary issue. Therefore, achieving the objectives of this global goal will require international collaboration on setting national objectives and ensuring transboundary connectivity. In some cases, this would involve national objectives that exceed 30% area protection (Visconti et al. 2019, Yang et al. 2020).

Quality elements: The Quality elements in Target 3 focus on several distinct aspects:

Areas of importance for biodiversity—given the uneven distribution of biodiversity on the planet, optimising placement of protected areas and OECMs is critical. It is possible to be far more efficient and effective in avoiding biodiversity loss by selecting areas with important biodiversity values (Butchart et al. 2015), as is now addressed by the global standard for Key Biodiversity Areas (IUCN 2016). The current protected areas system has not been well optimized for biodiversity conservation (Venter, 2018), although it has made significant contribution to halting species loss (Barnes et al. 2016).

… ***and its contributions to people***—the importance of nature’s contributions to people, which always result from biodiversity, is also emphasised given the importance of many PAs and OECMs, as well as intact and shared habitats (see three conditions section below) for Indigenous Peoples and Local Communities. Incorporating peoples’ needs induces significant trade-offs for spatial optimization with solely a biodiversity focus (Mehrabi et al. 2018, Schleicher et al. 2019). Thus, a larger area under protection is needed when both biodiversity and NCPs are considered, so implementing this target equitably requires extensive, well informed and coordinated planning within countries (see Ecosystems and Target 1 Brief) and at local levels (Gurney et al. 2021, Obura et al. 2021), as well as internationally.

Effectively managed—there is now considerable literature that successful biodiversity outcomes at the site level are most often driven by effective management (Geldmann et al. 2018, Gill et al. 2017). Failures in achieving protected area outcomes are most often a result of lack of investment in management, including of drivers and pressures that impact protected areas from outside their boundaries, and staff capacity. Achieving Target 3 will require significant investments and capacity building in PAs and OECMs, which at 30% of the planet, will be the largest land and sea use category.

Equitably governed—protected areas and OECMs have no social licence without a shared voice in decision-making and equitable benefit sharing. There are legitimate concerns that increasing protection to 30% of land and sea area will displace or adversely impact indigenous and local communities. With new approaches and legitimacy (see Target 21 and the theory of change of the GBF) protected areas should strengthen and recognize local governance. It is well established that Indigenous and community-governed territories often effectively retain their biodiversity conservation values (Schuster et al. 2019).

It is also clear that protecting at least 30% of the earth will not occur without the leadership, support and partnership of Indigenous Peoples and local communities. Protected and conserved areas can provide enormous benefits at the local level, but they should be established and managed with due regard for human rights (Tauli-Corpuz et al. 2020, Ricketts et al. 2019). Conservation works best when it is equitable: based on full participation, shared and transparent decision-making, rights-based approaches, and fair benefit sharing (Borrini-Feyerabend et al., 2013). The 30% target provides a huge opportunity to strengthen security of tenure and support to IPLC-led conservation by demonstrating the global environmental values of such management.

Biodiversity representative—the distribution of protected areas and OECMs should represent the full range of nature so that the range of genetic diversity, species and ecosystems have some level of area-based conservation. Representativity can be indicated by (a) coverage of threatened species and ecosystems and (b) coverage of all species and ecosystems in protected areas. Recognising that extinction risk has only been assessed for 7% of species, representativity can be indicated by both tracking how many species listed as threatened by IUCN are within protected areas, and how well protected areas match overall biodiversity richness (including endemicity and rare species). A methodology for mapping overall biodiversity and including threatened species has been demonstrated for the ocean (Zhao et al. 2020, Jefferson et al. 2021). Similar approaches for terrestrial and freshwater environments are available (Chape et al. 2005, Juffe-Bignoli et al. 2016, Bastin et al. 2019).

Well connected—biological connectivity between protected areas and OECMs, and their intervening land and seascapes is essential for the integrity of the sites, allowing daily and seasonal species movement, dispersal, and adaptation to climate changes (Hilti et al. 2020). Area-based conservation needs to move from being site-based to network-based. Connectivity is a concern across marine, terrestrial, and freshwater environments. In the sea, connectivity is assured by maintaining suitable habitat along current flows, and by preventing damaging practices that fragment ecosystems (e.g., trawling, and sedimentation from rivers). On land, connectivity can be increased by increasing the size of individual PAs and OECMs, improving the integrity or condition of natural habitats, and linking sites through natural and semi-natural linear features, such as along riverbanks, hedgerows, etc. In freshwaters, connectivity can be increased by removing artificial physical barriers to migration, reducing sedimentation, and pollution that restricts species dispersal.

Integrated into the wider landscapes and seascapes—protected areas and OECMs need to be managed so they are integrated into surrounding landscapes and seascapes. This aspect is complementary to the element on spatial planning in Target 1 and could potentially be addressed under the component on 'biodiversity inclusive' planning in Target 1.

Relationship to the United Nations Sustainable Development Goals

Target 3 addresses directly the United Nations Sustainable Development Goal 15 (Life on Land) and Goal 14 (Life on Water).

National Implementation of the "at least 30%" as a global target:

The Global Biodiversity Framework is a global strategy for biodiversity conservation, meant to be implemented according to national conditions. All countries might not be able to protect 30% of their lands and seas in protected areas and OECMs and some countries might need to protect more than 30% of their lands and seas. The Ecosystem Science Brief (sections 2b and 2c) presents some hypothetical illustrations of national implementation of area-based targets (1, 2, 3 and 10) illustrating differential implementation of Target 3 according to national circumstances.

A useful approach to understanding country-based implementation uses 3 generalised ecological conditions according to levels of human impact (Locke et al. 2019). The general types of *in-situ* conservation actions that Parties may consider can vary across the 3 conditions:

Condition 1—Cities and Farms (17.7 percent of the terrestrial world):

- Increase conservation efforts to secure endangered species and protect all remaining primary ecosystem fragments.
- Mainstream sustainable practices such as protecting good farmland, practising productive regenerative agriculture, and keeping nitrogen out of freshwater.
- Maintain pollinators and increase ecological restoration.
- "Green" cities to reduce carbon emissions, prevent urban sprawl, and provide access to nature for urban dwellers' health and well-being.
- Small percentages of these areas might qualify for Target 3 but are valid under other targets of the GBF.

Condition 2—Shared Landscapes (55.7 percent of the terrestrial world):

- Establish "biologically representative and well-connected systems of protected areas" while increasing coverage of protected and conserved Key Biodiversity Areas.
- Restore and maintain ecological processes and viable populations of native species (ensure area protected is in the range of 30–75% per ecoregion).
- Across landscapes integrate sustainable natural resource extraction and activities such as tourism, grazing and use of wildlife (where appropriate and sustainable) with indigenous knowledge and well managed, equitable and properly funded PA networks
- Ensure sufficient natural or native habitats to local levels at the square kilometer scale (Garibaldi et al. 2021).
- Areas may qualify for PA and/or OECM criteria under Target 3, sizes may be on the smaller side, but integrated into broader landscape and seascape planning (Obura et al. 2021).

Condition 3—Large wild areas (26.5 percent of the terrestrial world):

- Retain overall ecological integrity and associated global processes such as carbon storage and rainfall generation, fluvial flows and large migrations.
- Prevent further fragmentation allowing only rare nodes of intense industrial development enveloped in a largely wild matrix.
- Secure indigenous knowledge and livelihoods.
- Establish large PAs and indigenous and community conserved areas, may provide the largest contribution of area within countries to Target 3.

Maps are available showing where each country fits into the 3 conditions https://naturebeyond2020.com/3conditions/.

In this classification, countries like Belgium, Rwanda, India, and Germany have little or no condition 3 so would not have high responsibility for area contributed under Target 3, while they may nevertheless make irreplaceable contributions to conservation for certain globally critical ecosystems (e.g., Sundarbans) and species (e.g., mountain gorillas, tigers) and protected areas and OECMs within condition 2 landscapes. Countries like Canada, Russia, and Brazil, with 30–60% area under condition 3, would have a high global responsibility for maintaining it. The equity in implementation of CBD targets comes from the resource mobilisation package (see Ecosystem Science Brief).

A similar framework for the 3 conditions can be applied to marine and freshwater habitats, and is currently under development by the IUCN-WCPA's Beyond the Aichi Targets Task Force.

3) Indicators

Most recent indicators (as of 14 March 2022)

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

3.0.1 Coverage of Protected areas and OECMS (by effectiveness)

- By ecosystem
- By Key Biodiversity Area
- By effectiveness category (Protected Area Management Effectiveness or PAME)

Component indicators

3.1 Area protected and conserved. The effects of management on biodiversity are better communicated by grouping that present IUCN Protected Area Categories according to their effect on biodiversity, i.e., those that:
(a) fully (Ia) and
(b) partly protect (Ib, II) biodiversity and aim for it to be in a natural state, and
(c) other categories that limit focus to particular species, habitats or landscapes (III to VI).
3.2 Areas of particular importance for biodiversity to be protected and conserved
3.3 Effective management and equitable governance of the system of protected areas and other effective area-based conservation measures
3.4 Connectivity within the system of protected areas and other effective area-based conservation measures

Complementary indicators

t3.1. Protected area downgrading, downsizing and degazettement (PADDD)
t3.2. Status of Key Biodiversity Areas
t3.3. Protected area coverage of key biodiversity areas
t3.4. Protected area coverage of coral reefs and other marine biomes
t3.5. IUCN Green List of Protected and Conserved Areas
t3.6. Number of hectares of UNESCO designated sites (natural and mixed World Heritage sites and Biosphere Reserves)
t3.7. Proportion of terrestrial, freshwater and marine ecological regions which are conserved by protected areas or other effective area-based conservation measures
t3.8. Species Protection Index
t3.9. Protected Area Connectedness Index (PARC-Connectedness)
t3.10. Ramsar Management Effectiveness Tracking Tool (R-METT)
t3.11. Number of protected areas that have completed a site-level assessment of governance and equity (SAGE)
t3.12. Number of certified forest areas under sustainable management with verified impacts on biodiversity conservation
t3.13. Percentage of biosphere reserves that have a positive conservation outcome and effective management
t3.14. Extent of indigenous peoples and local communities' lands hat have some form of recognition

Possible additional indicators

Additional work is being led by UNEPs World Conservation Monitoring Centre to develop appropriate measures of protected area quality.

Measuring quality of protection and conservation

Area indicators for PAs and OECMs aggregate to contribute to the area headline indicator for Goal A, 'A.0.1. Extent of selected natural and modified ecosystems'.

However, no headline indicator has been identified corresponding to the quality elements of Target 3 and the ecosystem integrity elements of Goal A. Effective management under Target 3 should contribute directly to biodiversity condition in the areas managed, so relevant ecosystem integrity indicators should be included in the monitoring framework under development. As noted in the Monitoring Brief (section 'Data collection, curation and sharing of existing knowledge on biodiversity'), the primary resource for such data is in local, national and regional monitoring programmes established for varied purposes, providing primary data that could be integrated to serve the purposes of monitoring effective implementation of the GBF. These may include:

- Primary measures of ecosystem condition, such as primary productivity, intactness, fragmentation and structural integrity for forests (Naase et al. 2018, Hansen et al. 2019), productivity and phenology for grasslands (Weber et al. 2018), or corals, algae and fish diversity and abundance for coral reefs (Souter et al. 2021, Obura et al. 2019). These measures will allow for bottom-up population of the monitoring framework from existing national and long-term monitoring programmes and provide a focus for resource mobilization for the GBF monitoring framework.
- Integrated ecosystem indices such as the Red List of Ecosystems (Keith et al. 2013, Rodriguez et al. 2011), which is a well-established methodology applicable across any ecosystem worldwide, incorporating ecosystem-specific variables such as in the examples above, and incorporates the spatial and temporal aspects needed to assess status and potential future trends in the state of ecosystems from national to global scales.
- Complementary indicators for the extent and condition of critical ecosystems, including primary forests (Hansen et al. 2019).

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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 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 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 that also addresses Targets 1 and 2 in detail.

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

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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.

Target formulation **-** 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).

1) 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).

3) 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

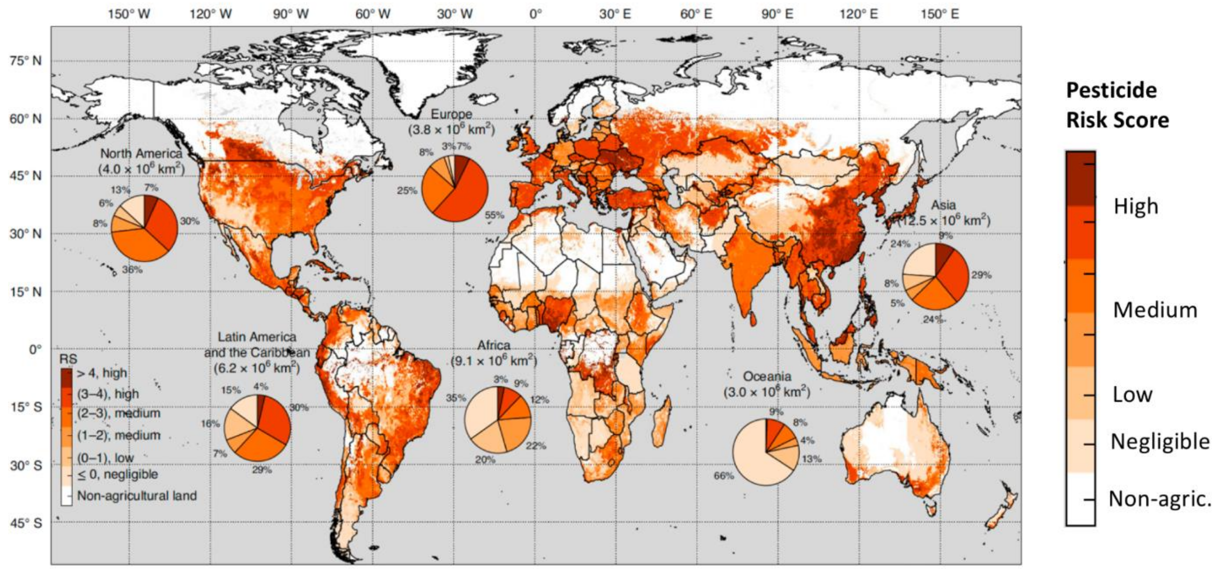


Figure 1. Global scale map of pesticide risk. "64% of global agricultural land is at risk of pesticide pollution by more than one active ingredient, and 31% is at high risk. Among the high-risk areas, about 34% are in high-biodiversity regions." Tang et al. (2021, see also description below in Box 1)

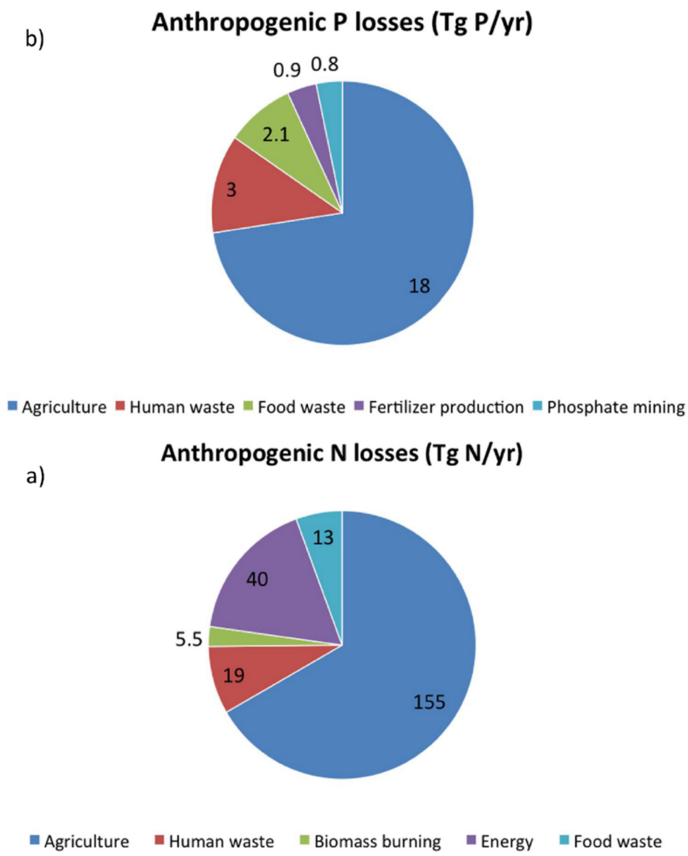


Figure 2. Sources of nitrogen (N) and phosphorus (P) losses to the environment at the global scale. from Kanter & Brownlie (2019)

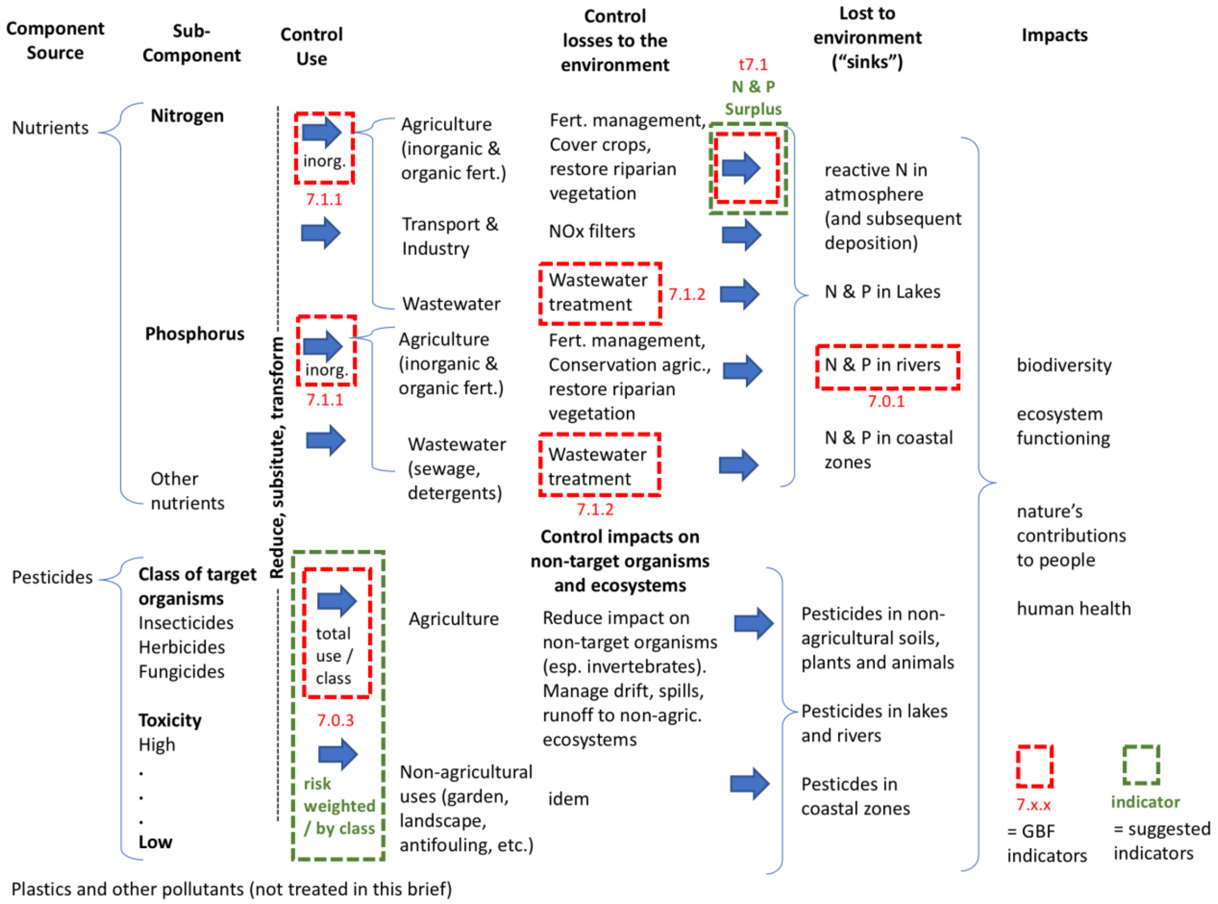


Figure 3. Summary of sources of nutrient and pesticide pollution; means of reducing pollution by controlling use or losses to the environment; proposed indicators for the GBF; and impacts. Indicators currently in the GBF are in red boxes. The headline indicator for nutrients is N and P in rivers lost 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).

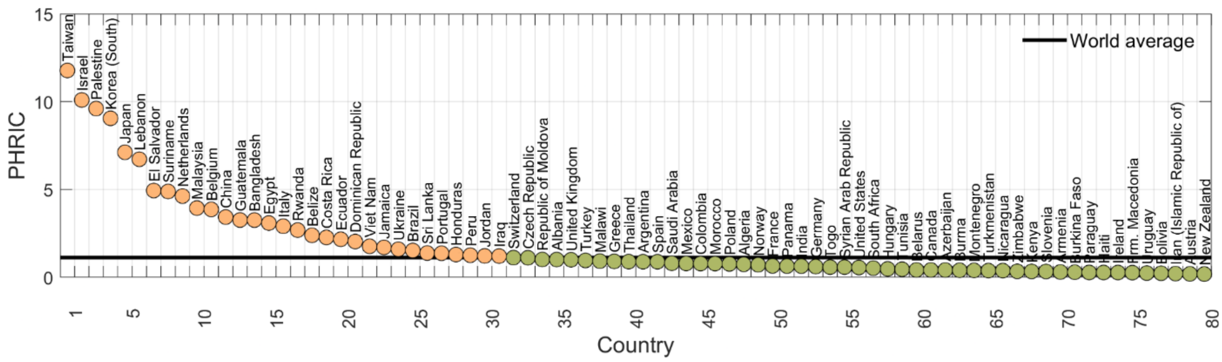


Figure 4. Pesticide health risk index of countries (PHRIC). 31 countries worldwide have PHRIC higher than the world average, where PHRIC aggregates the pesticide load (toxicity and mass), people exposure, and potential intake via inhalation and drinking water (Maggi et al. 2021).

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

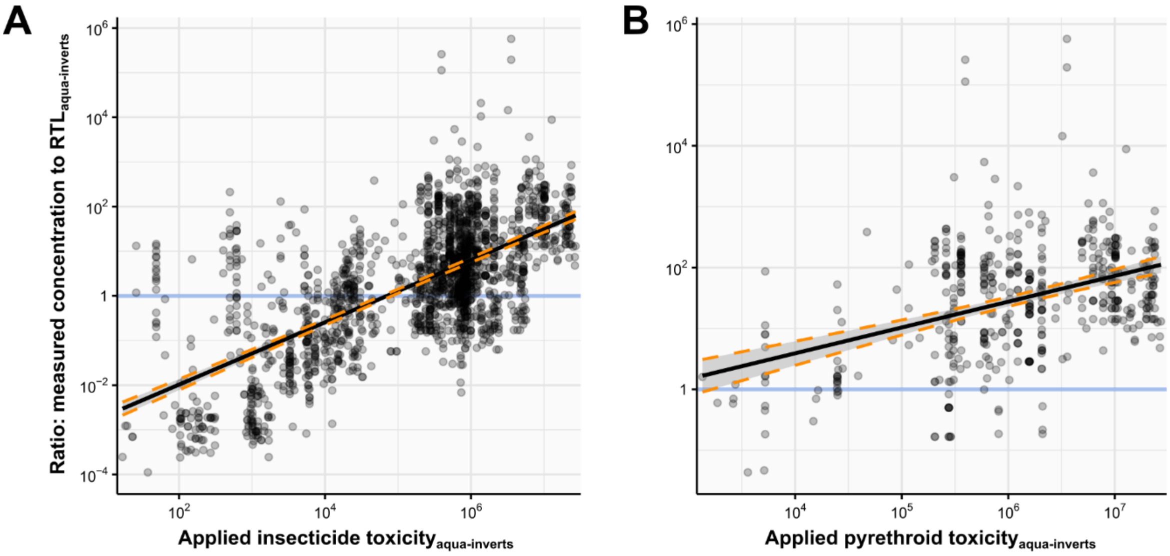
------------------------------ Box 1. Risk based indicators for pesticides —-----------------------

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.

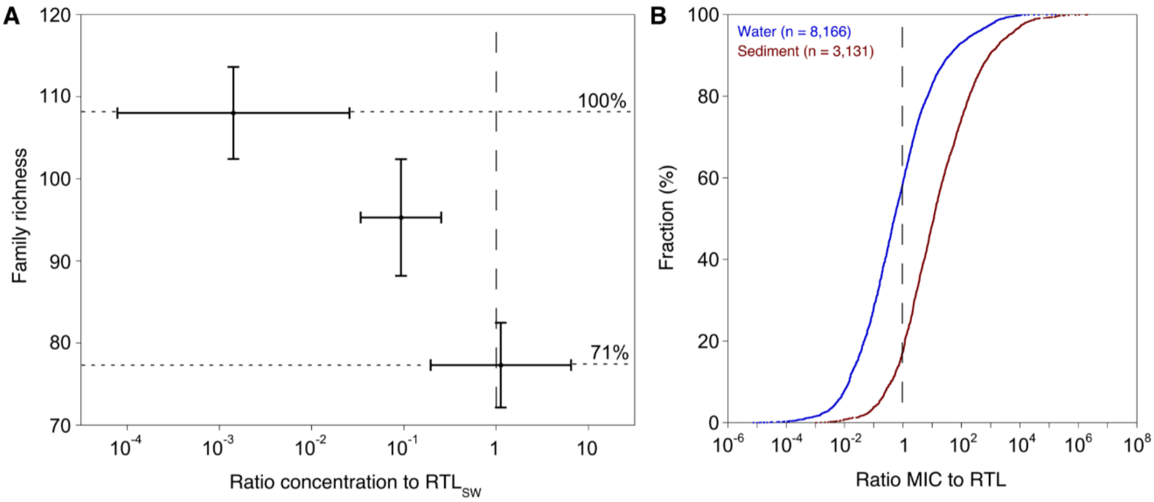
Although studies have shown that toxicity-weighted use is the strongest predictor of the potential impact of a pesticide on the environment, TAT relies on the assumption that pesticide use and its effects on organisms are robustly connected to each other at large scales (Schulz et al. 2021). This assumption 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

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- 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***

"Contribute to mitigation and adaptation" – 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 $GtCO_2e$ 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 $GtCO_2e$ 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 $GtCO_2e$ 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 $tCO_2\text{-eq}^{-1}$, is 8-14 $GtCO_2\text{-eq yr}^{-1}$ (high confidence). 30-50% of this potential is available at less than USD20/tCO_2e and could be upscaled in the near term across most regions (high confidence). The largest share of this economic potential [<u>4.2-7.4 $GtCO_2e\ yr^{-1}$</u>] 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 — <u>by 2025</u> — and absorb carbon while avoiding emissions at a rate of <u>10 gigatonnes of CO_2 {equivalent} per year</u> (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 <u>by 2030</u>, nature-based solutions implemented across all ecosystems can deliver emission reductions and removals of <u>at least 5 $GtCO_2e$ per year, of a maximum estimate of 11.7 $GtCO_2e$ per year</u>. 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 <u>greater than 5 $GtCO_2e$ per year</u>.

- 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)

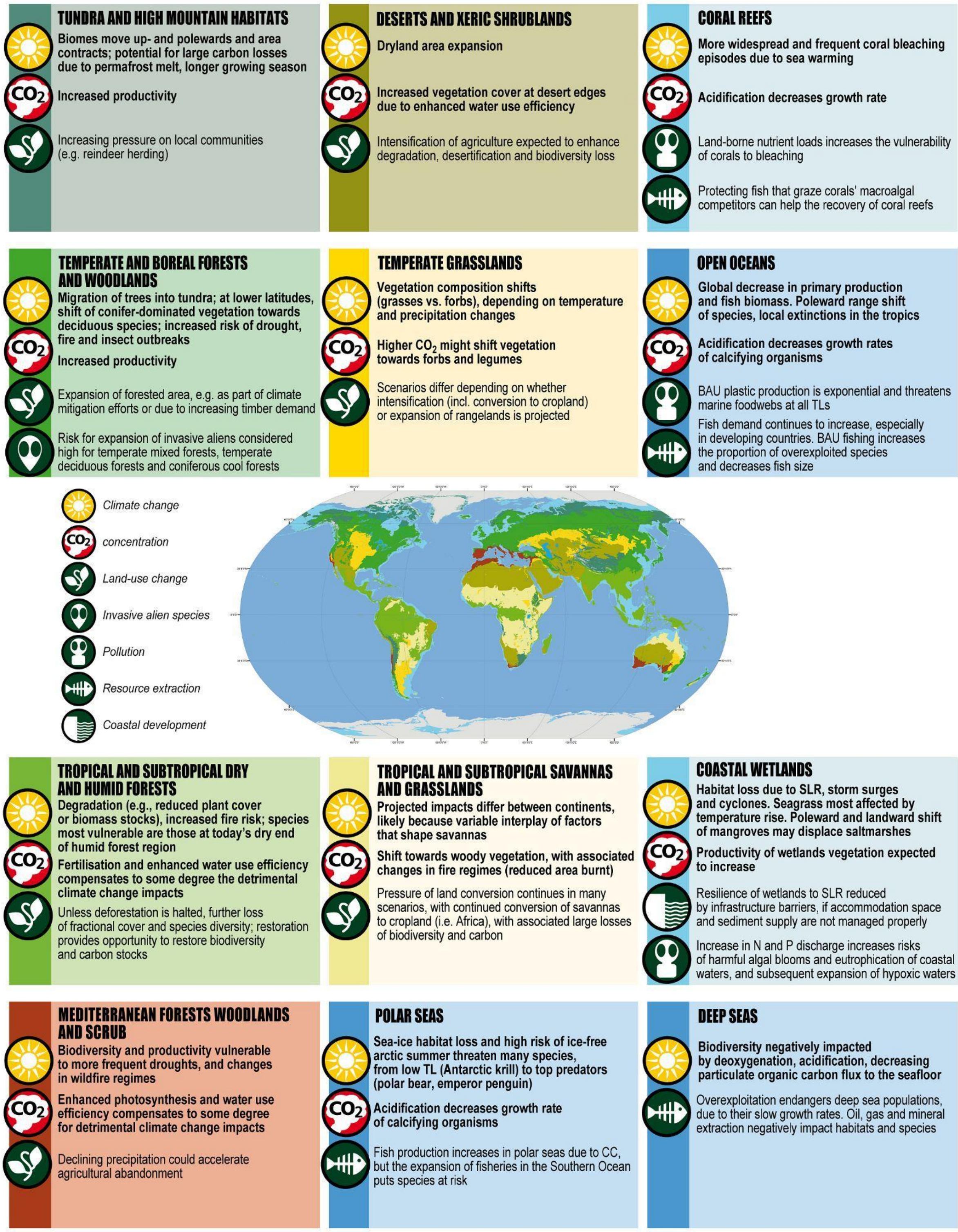


Figure 2: "Nature-based solutions" aid adaptation to, and mitigate against the effects of, climate change while restoring and protecting biodiversity. (Source: E. Archer, pers. communication)

Nature-based solutions

Actions	Terrestrial	Freshwater	Marine
Protect biodiversity	Protect native forests, bush, and grasslands	Stop pollution and sedimentation into streams, rivers, ponds, lakes.	Ban seabed trawling and dredging
	Control introduction and spread of invasive species and pests		
Reconnect habitats and populations	Use riverbank and hedgerow corridors to connect protected native habitats		Restrict fragmentation of habitats by coastal development and seabed trawling and dredging
	Reduce habitat and species loss outside protected areas to add species dispersal (corridors)		
Living with nature	Environmentally sustainable agriculture, tourism, and other land and freshwater uses		Environmentally sustainable aquaculture, fisheries, tourism,
Restoration and recovery	Rehabilitate old mines, quarries and industrial lands	Stabilise riverbanks. Remove weirs and artificial barriers to fish migration.	Ban removal marine life and habitat fishing in selected areas to allow passive recovery of habitats, natural population structure, and food webs
Rewilding	Reintroduce extirpated native species		
Reduce erosion, soil loss,	Plant forests and controlling grazing to enable uplands to absorb rainfall and reduce flash-floods		Protect sand-dune systems from erosion due to human and farm animal trampling.
Control flooding	. 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.		
Urban development	Concentrate development to more cost efficiently manage transport and waste management infrastructure	Limit upland development to protect freshwater quality.	Ban construction in areas at risk of sea level rise and associated storm surges.
Greenhouse gas mitigation	Reforestation (especially mangroves); Revegetation; Fewer farm mammals	Repair and expand wetlands to capture and deposit carbon in soils.	Limit seabed disturbance by trawling and dredging that releases CO_2 and CH_4. Eliminate harmful fishery subsidies.
	Reduce use of fossil fuels and reapply subsidies to renewable energy sources.		
Carbon sequestration	Allow biodiversity to flourish and capture CO_2 from the air and sequester it in biomass, soils and sediments.		
	Manage forestry to maximise in situ food web biomass.	Rebuild fisheries to maximise in situ food web biomass.	
Social	Communicate information on the benefits of adaptation measures to the public		
Political and economic	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		
Scientific	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.		
	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.		

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)

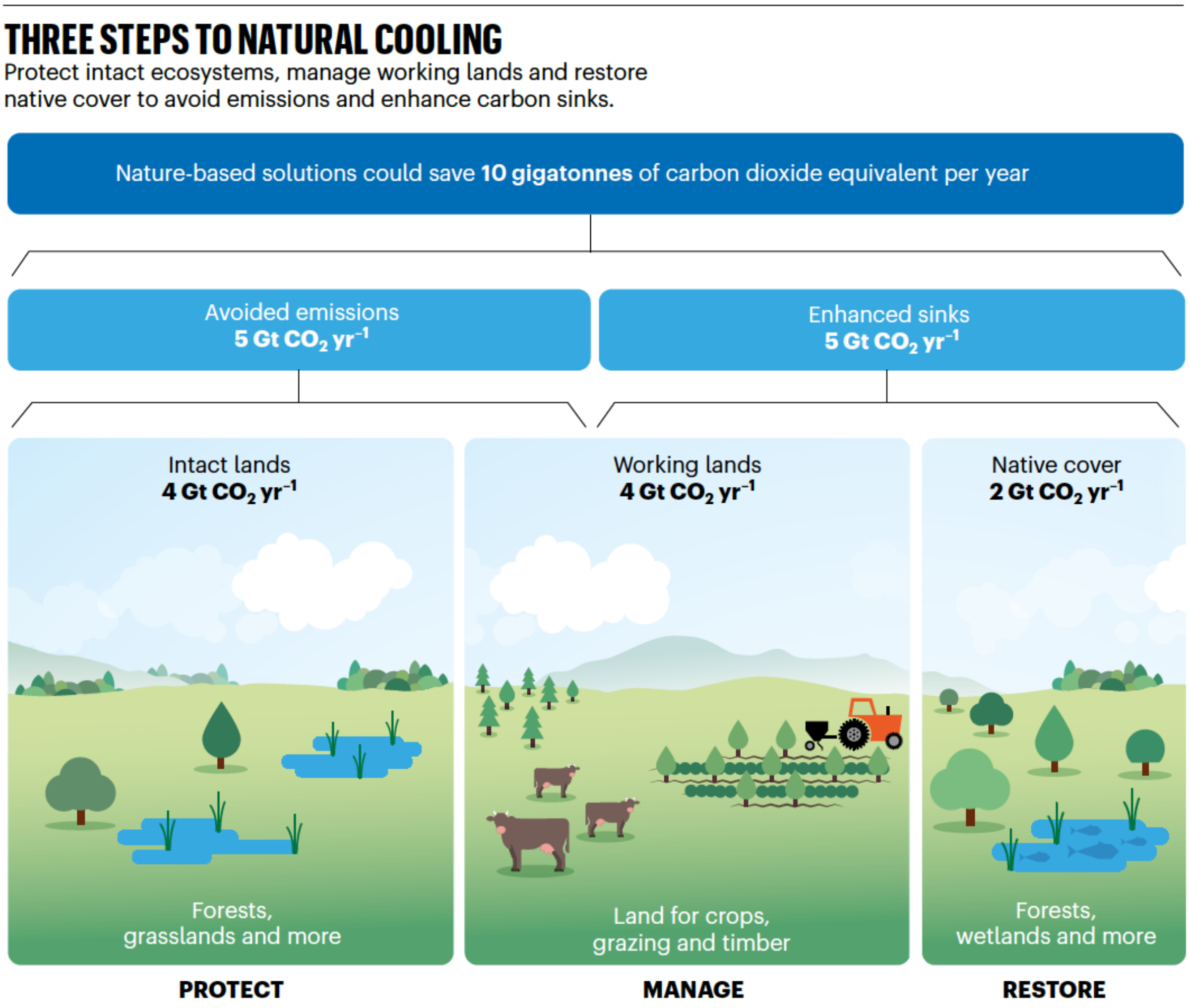
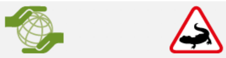


Figure 5. Estimates of climate mitigation potential and biodiversity co-benefits or trade-offs of a wide range of ocean- and land-based mitigation options. (Source: Smith et al. 2022).

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_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	Mitigation potential	Possible adaptation potential	Positive impacts on biodiversity
Biodiversity conservation	0.9 Gt CO_2e-e yr^{-1}	Likely many millions	High	Mitigation potential	Adaptation potential	Positive impacts on biodiversity
Enhanced weathering of minerals	0.5–4.0 Gt CO_2e yr^{-1}	No global estimates	Insufficient data to make judgement	Mitigation potential		
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]	Mitigation potential		Negative impacts on biodiversity
On-shore wind	Depends on what energy source is substituted	No global estimates	Low	Mitigation potential		
Solar panels on land	Depends on what energy source is substituted[6]			Mitigation potential		
(c) Demand changes (related to land)						
Dietary change	0.7–8.0 Gt CO_2e yr^{-1} (land)	No global estimates	High[7]	Mitigation potential		Positive impacts on biodiversity
Reduced post-harvest losses	4.5 Gt CO_2e yr^{-1}	320–400 million people	Medium/High	Mitigation potential	Adaptation potential	Positive impacts on biodiversity
Reduced food waste (consumer or retailer)	0.8–4.5 Gt CO_2e yr^{-1}	No global estimates	Medium/High	Mitigation potential	Adaptation potential	Positive impacts on biodiversity
Management of supply chains	No global estimates	>100 million	Medium[8]		Adaptation potential	Positive impacts on biodiversity
Enhanced urban food systems	No global estimates	No global estimates	Medium			Positive impacts on biodiversity

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.

TARGET 10 – PRODUCTIVE SECTORS

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.**This science brief addresses the inclusion of sustainable agriculture of Target 10**

The analysis in this brief focuses on the wording elements of Target 10, definitions of key terminology, evidence review of biodiversity in agriculture and assessment of the adequacy and availability of indicators for tracking the 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 10. Ensure all areas under agriculture, aquaculture and forestry are managed sustainably, in particular through the conservation and sustainable use of biodiversity, increasing the productivity and resilience of these production systems***

This analysis focuses on sustainable agriculture emphasizing the current pressures that agriculture puts on nature which are currently a major source of degradation, and on the potential of sustainable practices to regenerate natures contributions to people, notably food, fuel, and fibre production, but also non-production related contributions such as climate mitigation. It emphasizes that clear environmental performance metrics are necessary to monitor agriculture's transition to net positive environmental values and highlights existing metrics validated by the scientific community.

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) References

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KEY MESSAGES CONCERNING THE SUSTAINABLE AGRICULTURE COMPONENT OF TARGET 10

- Sustainable management and use of terrestrial and aquatic food production systems are key to reducing pressures on biodiversity and preventing the transgression of planetary boundaries.
- Between 18 to 33% of agricultural lands currently have insufficient biodiversity: this degrades ecosystem functions, creates unacceptable risk for food security, and compromises the resilience and sustainability sought in Target 10.

Sustainability:

- The approach to sustainability across various production systems needs clarity on its operationalization by including metrics to analyse and monitor the i) change in biodiversity, ii) production of nature's contribution to people (NCP), iii) interlinkages between biodiversity and production, iv) relationships between biodiversity and demand-side factors, and v) diversification strategies within land uses, between land uses and across landscapes or basins. The GBF would profit from greater clarity on this in the wording of Target 10 and in the choice of indicators for this target.

Sustainable Production:

- Sustainable production includes many management approaches that can make agriculture sustainable such as: i) diversifying production systems, ii) making use of locally adapted and nutritious crop species and varieties, iii) ensuring water use is within the limits needed to maintain environmental flows and iv) maintaining complexity by embedding natural habitat in agricultural landscapes. The GBF, perhaps in the glossary, would benefit clarification of sustainable agriculture practices.
- Greater integration of biodiversity, including dietary diversity, in sustainable production is necessary for improving health, eliminating hunger and achieving nature-positive outcomes.
- Enhancing crop diversity in production systems and landscapes to produce more diverse foods can be a win-win solution for both improved nutrition and biodiversity.
- Regenerative agricultural practices can generate additional critical ecosystem services by maintaining biodiversity in and around agricultural lands, which when implemented at scale, offer potential benefits including but not limited to carbon sequestration, habitats and connectivity for biodiversity including pollinating and pest regulating species.
- Innovation and investment in productive and sustainable production can address trade-offs and close both yield and NCP production gaps.
- Investment is needed to close the production gap of crops contributing to healthy diets, in line with Sustainable Development Goals (SDGs) 2 and 3, including urgent investments in undervalued and underproduced agrobiodiversity vital to dietary health.

Policies:

- Agriculture and biodiversity need to be more strongly integrated into global policies, practices and other public sector instruments across all sectors of government. These public sector instruments should be guided by science-based targets and true cost accounting to incentivize transitions to sustainable agriculture, recognizing producers (e.g., farmers) as producers of both material goods and of environmental benefits and to make healthy food affordable and available.
- More investment is needed to build the capacity of scientists, policy officials and institutions in the Global South, filling the knowledge gaps on agricultural systems.
- Sustainability in trade can be supported through direct investment in agriculture producing countries to support them in complying with the standards, due diligence requirements, tracing mechanisms, enforcement and border tariffs to reduce adverse impacts of consumption patterns on ecosystems and biodiversity.
- The aspects advanced through target 10 help deliver several of the other targets of the GBF as well as the SDGs, especially SDG 2, 3, 12, 13 and 15.

BACKGROUND ON THE SUSTAINABLE AGRICULTURE COMPONENT OF TARGET 10

Agriculture is the largest single driver of environmental degradation and biodiversity loss, responsible for over 30% of global greenhouse gas (GHG) emissions, 70% of freshwater use and 80% of land conversion. Thus, agriculture must be part of the solution to solve the current global environmental challenges. This brief provides scientific evidence to guide the decision-making process around the inclusion of food systems in the post-2020 global biodiversity framework (GBF). Ultimately, the scientific and technical guidelines on biodiversity will require political decision, collective action and commitment across sectors to achieve the transformation required on the ground.

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

Target 10 refers to the nearly 40% of the earth's ice-free surface and the growing portions of freshwater and marine ecosystems (Costello et al. 2020) used to produce food and other goods with varying levels of intensity to produce material goods essential to people's lives and livelihoods. All areas should be sustainably managed because unsustainable exploitation and practices must be eliminated as evidence shows these have driven the transgression of planetary boundaries (Springmann et al. 2018, Willett et al. 2019, Rockström et al. 2020). This is compatible and complementary to target 1, which calls for "100% spatial planning that is 'biodiversity inclusive'.

The target and the headline indicator should be clearer on what is intended by the term 'sustainable', including clear metrics tracking the change in biodiversity, and the NCP's it provides. The term 'production' here should include both material good production and NCP production including provisioning nutritious foods and ecological functions that support material good production, regulate climate, water, nutrient, and pollution in relation to planetary boundaries (Rockstrom et al. 2009, Steffen et al. 2015, DeClerck et al. 2016, Rockström et al. 2020, DeClerck et al. 2021b).

Much of the justification provided below is focused on agricultural production, as that is where the greatest evidence has been collected, and interlinkages between biodiversity and production, of a wide portfolio of benefits, are clearer. Comprehensive reviews of the evidence for roles of biodiversity in food production, including those prepared for the United Nations Food System Summit strongly inform this Science Brief (DeClerck et al. 2021b, a).

We note that most of the evidence presented here relates to the roles of and impacts on biodiversity in terrestrial food production systems and that aquatic systems are under-valued and studied (Costello et al. 2020), but have high potential (Gephart et al. 2021). It delves into the relationships between biodiversity and diets or demand-side factors (areas not addressed but also relevant to sustainability that include production factors such as the practices used, pollution and waste in production and supply chains).

Other similar arguments can be made with other production systems (e.g., fisheries, forestry, aquaculture) so the logic of producing sustainably can be extended across those and other production systems in operationalizing target 10, especially as many of these systems are interconnected (e.g., terrestrial and aquatic). The areas addressed by target 10 (production scapes on lands and waters) help deliver many of the other targets of the GBF as well as the Sustainable Development Goals (SDGs), addressed in more detail below.

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

This target refers to lands and waters managed by people for the production of goods which support healthy and enjoyable lives. The target should ensure inclusion of the diversity of production systems that depend on lands and waters, and their biodiversity. These include agriculture, aquaculture, fisheries, forestry which can more simply be referred to as "production systems". This target has an important relationship to target 1. First, it covers the 40% of ice-free land under production systems (Willett et al. 2019, Leclère et al. 2020) that must meet the criteria of "100% spatial planning that is biodiversity inclusive" in the first part of target 1. Second, improving the productivity in production scapes, along with consumption side interventions is a necessary precondition to avoiding the further loss of intact landscapes and wildernesses cited in target 1. Finally, lands and waters under production systems addressed in this target are distinct from intact ecosystems and wilderness areas addressed in the second part of target 1, and actions must be complementary across their boundaries.

There are concerns that sustainable production is not compatible with sufficient production, notably with food security. There are some suggestions that food production may need to increase 60% by 2050 which would be a challenge as population growth is only 33%, that 30% of food is lost and wasted, and that overconsumption, notably of animals sourced foods, drives environmental pressures. Improved sustainable production practices combined with healthy diets, reducing food loss and waste, and trade, are necessary contributions which permit sustainable production, and significant conservation (Targets 1 and 3) (Benton & Bailey 2019, Willett et al. 2019, Leclère et al. 2020).

Converted lands used to produce food, fuel, fiber and other goods include 40% of global ice free total and converted rivers include 77% of rivers globally (Grill et al. 2019). Therefore regenerating ecosystem function in converted lands and waters is crucial to meet global climate, water, and biodiversity targets and goals, and to bend environmental curves (Tilman & Clark 2014, Tilman et al. 2017, Clark et al. 2020, Leclère et al. 2020). These converted systems can contribute to regenerating ecosystem functions, such as climate mitigation (Willett et al. 2019), and interventions to underpin assisted regeneration, such as landscape restoration, can promote ecosystem connectivity (Mbow et al. 2014, Griscom et al. 2017, Ripple et al. 2017, 2019, Amelung et al. 2020, Bossio et al. 2020, Clark et al. 2020, Lal 2020). More impactful, but production compatible innovations may be needed to regenerate carbon capture in production lands and waters.

Agroecology, *as an ecological science, focuses on the contribution of the conservation and sustainable use of* ***biodiversity*** *on enhancing the generation of ecosystem services (NCP's) to and from agriculture with the aim of* ***regenerating*** *these services. Diversification, agroecological, or regenerative agricultural practices are overlapping and include a diversity of management options from fields to landscapes* (DeClerck et al. 2021b).

The Food and Agriculture Organization of the United Nations (FAO) *and the High Level Panel of Experts (HLPE) Report #14* (FAO-HLPE 2019) *on agroecological and other innovative approaches suggests a concise set of thirteen agroecological principles related to: recycling; reducing the use of inputs; soil health; animal health and welfare; biodiversity; synergy (managing interactions); economic diversification; co-creation of knowledge (embracing local knowledge and global science); social values and diets; fairness; connectivity; land and natural resource governance; and participation as all necessary for the sustainable management of production lands and waters.*

GBF Glossary (CBD/WG2020/3/3/Add.2/Rev.1) - Sustainable agriculture and aquaculture. The vision of FAO for sustainable food and agriculture is one in which food is nutritious and accessible for everyone, and where natural resources are managed in a way that maintains ecosystem functions to support current, as well as future human needs. (FAO, http://www.fao.org/sustainability/background/en/)

Evidence Review:

In early 2021, thirty ecologists undertook a rapid evidence review of biodiversity in agriculture led by the CGIAR research program on Water Land and Ecosystems, with the following key messages (DeClerck et al 2021a, DeClerck et al. 2021b).

Agriculture is the largest single source of environmental degradation, responsible for over 30% of global GHG emissions, 70% of freshwater use and 80% of land conversion: food production and consumption remains the single largest driver of biodiversity loss (Foley et al. 2005, 2011, IPBES 2019, Willett et al. 2019). While too many still struggle from acute hunger, a growing number of individuals, including low and middle-income countries (LMICs), struggle to access healthy foods with 2 billion facing diseases related to overconsumption or poor consumption. Greater consideration for, and integration of, biodiversity, including dietary diversity, in sustainable production is necessary for improving health, eliminating hunger and achieving nature-positive outcomes. This diversity contributes to sustainable production (Tamburini et al. 2020).

In light of agriculture's vast environmental footprint, the broader food system must be a key part of the solution. Production systems as somehow independent of the natural world exonerated from environmental responsibilities are no longer compatible with global goals on food and nutritional security, climate security, environmental security and livelihood security (Ripple et al. 2017, 2019, Benton & Bailey 2019).

Healthy diets require dietary diversity, which requires greater crop diversity and agricultural biodiversity supporting production. Low dietary diversity is the common denominator for the 2 billion who continue to struggle with unhealthy diets (Remans et al. 2014, 2015, DeFries et al. 2015, Lachat et al. 2018). Increasing crop diversity in production systems to match consumptive needs is a means of achieving target 1 by reducing the net amount of land needed for food production, and target 16. Ensuring diverse healthy diets for all could avert up to 11 million premature deaths per year (Willett et al. 2019). **Enhancing production of more diverse foods can be a win-win solution for both improved nutrition and biodiversity [*High Agreement, Robust Evidence*]**.

It is possible to produce healthy diets for 10 billion people and halt the loss of biodiversity, securing its contribution to climate regulation and other planetary boundaries, despite significant challenges and trade-offs in several regions of the world, especially in developing economies **[*High Agreement, Medium Evidence*]**.

Sustainable production, notably of healthy diets, is dependent on increasing diversity in production landscapes. The majority of foods whose production must increase to ensure food and nutrition security are pollination dependent with important overlaps in malnutrition and pollination dependance (Chaplin-Kramer et al. 2014). At least 10-20% (Willett et al. 2019, Rockström et al. 2020, Garibaldi et al. 2021) of semi-natural habitat per km^2 is needed to ensure ecosystem functions, notably pollination, biological pest control and climate regulation, and to prevent soil erosion, nutrient loss and water contamination. **Today, 18-33% of agricultural lands have insufficient biodiversity to provide those services, an unacceptable risk for food security compromising the resilience sought by target 10 (Figure 1; DeClerck et al. 2021).**

Sustainability is dependent on diversification strategies within land uses, between land uses and across landscapes or basins which often are regenerative, synergistic and multipurpose, and can bolster ecosystem functions within resilient agricultural production systems. Regenerative agricultural practices can generate additional critical ecosystem services by maintaining biodiversity in agricultural lands. **At scale, these practices offer the potential to sequester 4.3-6.9 Gt CO2e year^{-1} [*Medium Agreement, Medium Evidence*], create 12-17 M km^2 habitat for biodiversity [*High Agreement, High Evidence*] and increase connectivity for biodiversity [*High Agreement, Limited Evidence*].**

There is no evidence that diversified production systems compromise food security – many agricultural diversification practices provide multiple complementary benefits (Garbach et al. 2016, Tamburini et al. 2020) [*High Agreement, High Evidence*]. Innovation and investment in productive and sustainable production can address trade-offs and close both yield and NCP production gaps (Costello et al. 2020).

<u>Means of achieving 100% Target 10</u>:

1. Agriculture needs to be more strongly integrated and mainstreamed into global policies and agreements and across all sectors.
2. A transition to managing agricultural systems as ecological systems (agroecosystems) is needed through the systematic adjustment of agricultural, land use and fisheries policies and practices guided by science-based targets and true cost accounting to incentivize long-term adoption of regenerative, carbon-sequestering and nature-positive production systems.
3. Critical investments in performance analysis across multiple dimensions and synergies of production systems are needed (e.g., increasing production, diversifying tree-crop composition, above or below ground carbon capture, soil health and measures of the ecological integrity of production systems). Global support and alignment for nature-positive production by scaling a

diversity of context-specific diversification practices will increase the resilience of food systems.

4. A coordinated, consensus-based, transformational adjustment of policies, incentives, regulations and other public sector instruments and public funds (as well as private) is needed to make healthy and sustainable food affordable and available for all while enabling farming communities to gain greater recognition and reward for actions that produce healthy foods as well as biodiversity and climate benefits. Closing policy implementation gaps is also fundamental.
5. Investment is needed to close the production gap of crops contributing to healthy diets, including whole grains adapted to local environments, fruits, nuts, vegetables and seeds to supply healthy diets at local, regional and global scales, in line with SDGs 2 and 3, including urgent investments in undervalued and underproduced agrobiodiversity vital to dietary health and integrating sustainable livestock production into cropping systems.
6. Investment is needed in research to fill knowledge gaps on agricultural systems of LMICs, including on building the capacity of scientists, policy officials and institutions in the Global South, increasing their capacities to engage with regional food system actors, and increasing the access and participation of LMIC scientists in global science-policy interfaces.
7. Financial markets need to shift investment flows away from unsustainable, unhealthy and socially unjust practices and into investments in tools, innovations, technologies and enabling environments that drive transformative change; food companies should integrate environmental, social and health risks into company disclosures.
8. International trade should be re-imagined so that higher-income countries take account of the adverse impacts of their consumption on ecosystems and biodiversity through trade in commodities, goods and services with lower-income countries. Sustainability in trade can be supported through direct investment in the producing countries to support them in complying with the standards, due diligence requirements, tracing mechanisms, enforcement and border tariffs.

Determining national contributions – in a national context, ‘global’ refers to 100% of land, freshwater and ocean territories, thus full coverage of all of these by spatial planning processes that meet the criteria and deliver the objectives of this target. The potential contributions of countries may be identified from integrating global prioritization analyses (top-down) with national (including local) aggregation and priority setting processes (bottom-up) to identify national targets. Aggregation of national contributions to the global target may be done nominally (by country) or by area, as relevant to each specific indicator. A growing number of environmental performance indicators related to sustainability in production lands and waters can now, or will shortly, be measured with remote sensing technologies.

3) Indicators

The most recent indicators (as of 14 March 2022) are listed below with **Headline in bold,** component indicator in plain and *complementary indicator in italics.*

10.0.1 Proportion of agricultural area under productive and sustainable agriculture

10.1.1. Average income of small-scale food producers, by sex and indigenous status (SDG indicator 2.3.2)

t10.1. Changes in soil organic carbon stocks

t10.2. Red List Index (wild relatives of domesticated animals)

t10.3. Red List Index (pollinating species)

t10.4. Proportion of local breeds classified as being at risk of extinction

Comments on indicators and potential new indicators

The existing list of indicators does not capture several aspects of agricultural management that impact negatively on biodiversity or that have the potential to positively contribute to biodiversity conservation. Critical is the absence of clear metrics around sustainability. The headline indicator under target 10 is 'proportion for agricultural area under productive and sustainable agriculture'. But, there is no information on what is considered sustainable and a risk that it includes only organic and conservation agriculture but not the many other management approaches and innovations, both traditional and modern, that can make agriculture sustainable, namely diversifying production systems, making use of locally adapted and nutritious crop species and varieties, ensuring water use is within the limits needed to maintain environmental flows, maintaining complexity by embedding natural habitat in agricultural landscapes.

The Food System Countdown Initiative (Fanzo et al. 2021) which includes contributions from over forty scientists in collaboration with FAO has proposed six key indicators domains for assessing the environmental sustainability of production systems. Critical to the success of the GBF are clear metrics of sustainability, notably those that relate to biodiversity, or its contribution to sustainable production as well as alignment of these metrics with other UN initiatives and commitments.

Domain	**Definition/Description**
Land and soil	Agriculture dominates global land use with approximately 1.5 billion hectares of cropland, of which 30-40% is used to produce feed, and 3.5 billion hectares of grazing land (Mbow et al. 2019). Together, these lands cover approximately 40% of the world's ice-free land (Ramankutty et al. 2018). Monitoring land use change is essential, as it is at the center of many environmental processes. Halting deforestation and land conversion will reduce GHG emissions, improve water cycles, and protect biodiversity; together with restoration, avoiding conversion has the potential to store 200-330 gigatons of carbon (Leclère et al. 2020). The concept analogous to land use for aquatic systems is the spatial expanse of inland waters and oceans used for aquatic capture food production.
Biosphere integrity	Biosphere integrity is a measure of the quantity and quality of natural systems and resources required to maintain nature's contributions to people and halt species extinction (Gerten et al. 2020; DeClerck et al. 2021). Within food production systems, it is nature's capacity to support food production which can be assessed as the quantity of semi-natural and or natural habitat per km^2. Studies suggest that 10% habitat per km^2 is a threshold beyond which NCPs are no longer provided (Willett et al. 2019), and that 20% per km^2 may be a more appropriate target (Garibaldi et al. 2021). Approximately 18-33% of production lands are below this threshold and target respectively (DeClerck et al. 2021). Edge density for land covers within 10x10km landscapes with at least 100ha agricultural land can provide a complementary surrogate (Figure 1).
Greenhouse gas emissions/capture	Food systems account for 21-37% of total GHG emissions, two-thirds of which come from crop and livestock production, land use, and land use change, and the remainder from processing, transport, and packaging (Poore & Nemecek 2018, Mbow et al. 2019, Clark et al. 2020, Crippa et al. 2021, Tubiello et al. 2021). Specific emissions of concern relevant to food systems are methane from enteric fermentation (in ruminant animals) and rice paddies; carbon dioxide from land use change, transport, and processing; and nitrous oxide from fertilizer application and manures. Production scapes, in addition to restored lands, remain the only known means of sequestering greenhouse cases for storage either in above or below-ground biomass (Griscom et al. 2017, Bradford et al. 2019, Amelung et al. 2020, Bossio et al. 2020, Chapman et al. 2020). Biological carbon capture is an essential critical metric for target 10.
Water use	Water scarcity constrains food systems and human well-being; an estimated 1.2 billion people experience physical water scarcity and another 1.6 billion have insufficiently-developed water resources (Molden et al. 2007). Food production is responsible for 70-80% of global freshwater "consumptive use"—surface and groundwater removed from the local water cycle—which can drive water

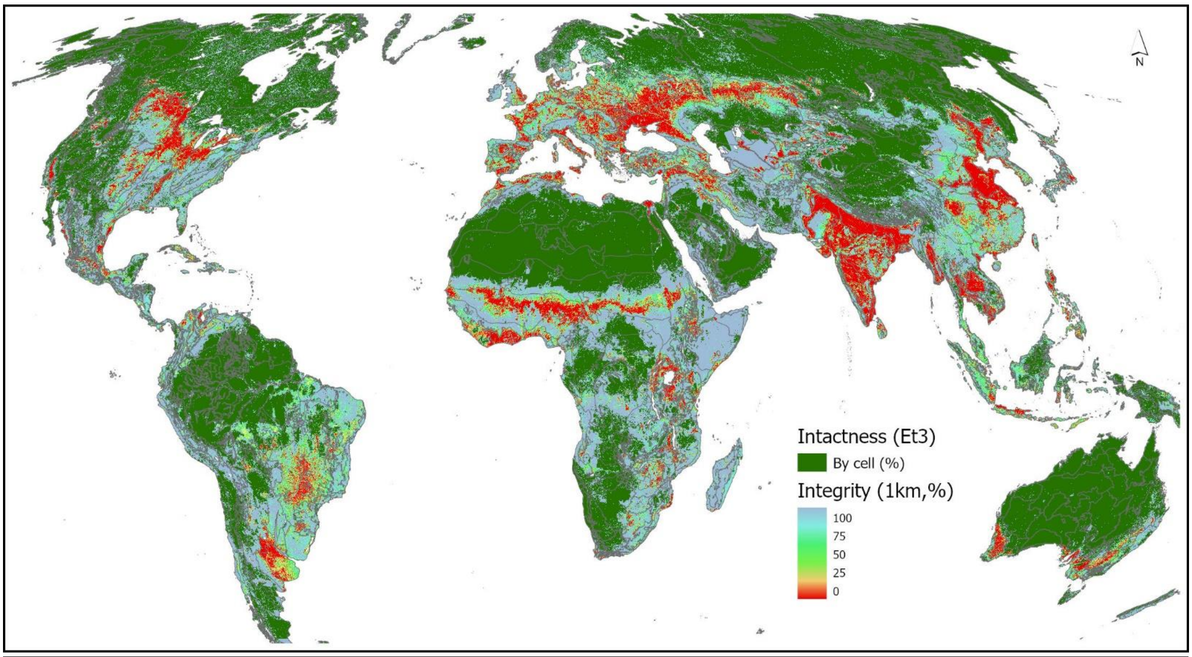
	scarcity if not locally replenished (D'Odorico et al. 2020). Sustainable use of water in production landscapes should not exceed ±20% of monthly environmental flows.
Pollution	Environmental pollution from food systems can be classified into four major categories: (1) nutrient loss and run-off (e.g., nitrogen, phosphorus) from food production into water bodies, land, and/or air, and soil degradation (Häder et al. 2020); (2) novel entities, notably biocides (e.g., pesticides, antibiotics) used in agricultural production systems; (3) particulate air pollution from food systems (e.g., burning residues or land clearing, air pollution caused, to a large degree, from manure and nitrogen fertilizer application) (Lelieveld et al. 2015); and (4) solid waste across food value chains (e.g., non-degradable plastics, other non-degradable unrecycled materials, excess animal waste not used as fertilizer, food waste of which 95% is estimated to be sent to landfills) (Melikoglu et al. 2013, Geyer et al. 2017, Yates et al. 2021). Established science-based targets for nutrient losses and soil degradation, and air quality are established (Steffen et al. 2015) and metrics have been proposed for biocides (Persson et al. 2022). Reductions in food loss require sustainable management of production systems, and are essential for achieving target 1 and target 16.
Agrobiodiversity Index	The diversity of plants, animals and microorganisms that directly or indirectly support food and agriculture is critical to achieving healthy diets and sustainable production systems. The Agrobiodiversity Index (Persson et al. 2022) (based on 22 indicators) provides a monitoring framework and informs food systems policy. Mean agrobiodiversity status scores in consumption and conservation are 14–82% higher in developed countries than in developing countries, while scores in production are consistently low across least developed, developing and developed countries. There is an absence of globally consistent data for several important components of agrobiodiversity, including varietal, functional and underutilized species diversity which are important components of target 10.

According to the key indicators domains noted above, and in light of the most recent indicators for target 10 (headline, component and complementary indicators), we note that the following domains are not sufficiently represented:

- Biosphere integrity in and around production systems
- Water use
- Pollution

We suggest implementing a pilot with a few Parties to look at the monitoring framework, their national data and own indicators vis-à-vis the domains suggested by the initiative to identify possible gaps and underrepresented domains in the current indicators. Other pilot initiatives can be organized as well according to the demand and needs of the Parties to embark on implementation.

Figure 1: Global raster map of remaining largely intact areas (green scale) covering approximately 49% of the earth's surface, and functional integrity (>10% seminatural or natural habitat per km^2 (blue/red scale). Areas in red have insufficient embedded biodiversity to provide the pollination, pest control, sediment and nutrient capture NCP's that support nature positive food production



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ECOSYSTEM AREA AND INTEGRITY OBJECTIVES OF THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK

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 quantitative and qualitive relationships of ecosystem level objectives of the GBF. In particular it focuses on the relationship between the ecosystem elements of Goal A and the action targets, in particular Target 1- Spatial Planning and Target 2 - Restoration. Note that connectivity is not treated as a separate topic in this brief: it is important and should be retained in Goal A.

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.

Structure of this brief

1) Background

   1.a) Overview

   1.b) Analysis of the area of natural ecosystems objective in Goal A and relationships to targets, focusing on Targets 1, 2 and 3

   1.c) Analysis of the ecosystem integrity objectives in Goal A and relationships to targets, focusing on Targets 1, 2, 3 and 10

   1.d) Analysis of the spatial planning objectives of Target 1

   1.e) Suggestions for rewording of Goal A, Target 1 and Target 2 to help create greater coherence and consistency in ecosystem objectives of the GBF

2) Quantitative and qualitative analysis of ecosystem area objectives

   2.a) Overview of natural ecosystem area in goals and targets

   2.b) Global analysis of natural ecosystem area objectives

   2.c) Translating global objectives for net gain in natural ecosystem area to national levels

3) Glossary

4) References

5) Background and Glossary Appendixes

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KEY MESSAGES CONCERNING THE ECOSYSTEM AREA AND INTEGRITY OBJECTIVES OF THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK

- Achieving net gains in the integrity of all ecosystems and in the area and integrity of natural ecosystems by 2030 and 2050 depends on concerted actions across all targets, and requires transformative change including considerable strengthening of conservation measures, systemic changes to increase the sustainability of production and consumption, and mobilisation of all sectors of society.
- "No net loss" and "net gain" policies for nature have generally been successful only when they set clear limits on losses, and have clear objectives for restoration such as strict like-for-like compensation of losses. Spatial planning and area-based conservation are critical elements of the GBF, but could be worded in a way that provides clearer objectives for reducing losses that build on Aichi Target 5. Similarly, the restoration target could include clearer qualitative and quantitative objectives for contributions to ecosystem area and integrity.
- Net gains in the area of natural ecosystems occur when the restoration of transformed to natural ecosystems is greater than losses of natural ecosystems. For example, net gains of 5% in the global area of natural terrestrial ecosystems by 2030 could be achieved with greatly reduced rates of loss of natural ecosystems and very ambitious restoration of transformed to natural ecosystems on the order of 350-400 Mha over the period 2021-2030. Global scale scenarios and other evidence indicate these reductions in losses and increases through restoration to achieve a 5% net gain in the area of natural terrestrial ecosystems are very ambitious but feasible.
- There is potential for quickly slowing and in some cases reversing losses the integrity of existing natural and managed ecosystems by reducing pressures leading to degradation. Gains in integrity can also be achieved through widespread restoration and rehabilitation actions. However, continued losses of natural ecosystems will have large negative impacts on ecosystem integrity; and some direct drivers of degradation, such as climate change, will inevitably intensify over the coming decade. In addition, newly created natural areas will have low integrity at first, and may take decades or even centuries to reach high integrity and so will make only modest contributions to integrity before 2030. The feasibility of net gains in ecosystem integrity is more difficult to evaluate than for the area of natural ecosystems, but several lines of evidence suggest that a 5% net increase in the integrity of natural terrestrial ecosystems by 2030 is near the upper limit of what is feasible.
- Directly translating global objectives, especially quantitative objectives, to national and local levels will likely result in sub-optimal use of resources and outcomes for biodiversity, as well as setting levels of ambition that are too low in some areas, and unrealistically high in others. Translation to national and local levels is more likely to succeed if it is developed inclusively with all actors, in particular indigenous peoples and local communities, considers past and present states and drivers of biodiversity, is resourced adequately, and incorporates strong, transparent governance. One way of assessing implementation and progress towards global goals would be to develop plans that take into account national contexts, conduct regular review of collective national contributions to global goals and then revisit national plans if needed. To facilitate this, indicators should be scalable so that national ambitions and contributions can be summed to assess their collective contributions and appropriate burden-sharing.
- One of the biggest challenges of the GBF is to meet objectives for biodiversity conservation and sustainable use at the same time, and ecosystem objectives are at the heart of this challenge. Spatial planning can play a major role in helping to reconcile these objectives and in finding synergies, and this could be more clearly reflected in the wording of Target 1.
- Clear definitions and consistent wording across goals and targets is essential for the implementation, monitoring and coherence of the GBF: this is lacking in the current draft. This brief provides advice on definitions and relatively modest changes in wording that would help clarify the levels of ambition, translation to national levels and overall coherence of the GBF.

BACKGROUND ON ECOSYSTEM AREA AND INTEGRITY

1.a) Overview

1.a.i) Area and integrity are complementary and not equivalent measures of the status of biodiversity, ecosystem functioning and nature's contributions to people (NCP)

Increasing the area of natural ecosystems and increasing integrity of natural and managed ecosystems are complementary but not mutually substitutable, so both are essential for protecting and restoring biodiversity, ecosystem functions and nature's contributions to people (Díaz et al. 2020). In addition, "...different actions are required in ecosystems that are predominantly 'natural' compared to those that are predominantly 'managed'. A goal of net gain of both area and integrity should only apply to 'natural' ecosystems because gain in their area will by definition have to come from 'managed' ecosystems. The increase in area and integrity of 'natural' ecosystems can be achieved both through restoration of 'managed' ecosystems back into a 'natural' state (increases in area first and then, over a longer time frame, also integrity) and by the restoration of degraded 'natural' ecosystems to a higher level of integrity (but no increase in area)." Díaz et al. (2020, Supplement 5). This brief, therefore, analyses separately the quantitative and qualitative relationships between area and integrity in Goal A and the action targets.

1.a.ii) Text of the first draft of the Post-2020 Global Biodiversity Framework for Goal A, Target 1 and Target 2.

The text of Goal A, Target 1 and Target 2 from the first draft of the GBF (CBD/WG2020/3/3) are provided below because they are the focus of much of the discussion in later sections. Negotiated text from the WG2020-3 in Geneva, March 2022 was not used as the basis of suggestions for rewording because the negotiated texts of Goal A, Target 1 and Target 2 are exceptionally difficult to interpret and comment upon (see CBD/WG2020/4/INF/1, including comments by the co-chairs).

> ***2050 Goal A: (ecosystem component) The integrity of all ecosystems is enhanced, with an increase of at least 15 per cent in the area, connectivity and integrity of natural ecosystems… 2030 Milestone A.1: (by 2030) Net gain in the area, connectivity and integrity of natural systems of at least 5 per cent.***
>
> ***Target 1. Ensure that all land and sea areas globally are under integrated biodiversity-inclusive spatial planning addressing land- and sea-use change, retaining existing intact and wilderness areas.***
>
> ***Target 2. Ensure that at least 20 per cent of degraded freshwater, marine and terrestrial ecosystems are under restoration, ensuring connectivity among them and focusing on priority ecosystems.***

1.b) Area of Natural Ecosystems

1.b.i) What is a 'natural' ecosystem and why is a clear definition important for the GBF?

The term 'natural ecosystem' broadly refers to ecosystems where the impact of humans on ecosystem composition, structure and function are low compared to natural factors. There is a wide range of estimates of the area of natural ecosystems because the criteria of 'low human influence' used in most definitions is ambiguous. This ambiguity arises from different value judgements and because there is a gradient between very low human influence (clearly natural) and very high influence (clearly not natural) with no clear dividing line in-between (Díaz et al. 2020, see Glossary Appendix-Box 2). Definitions of 'natural' generally centre around "low human influence" either measured by ecosystem integrity or by the degree of artificialisation (Riggio et al. 2020). Using this definition, about 50% of global land area is natural (range 48-56%, Riggio et al. 2020). Global scale impacts of humans like climate change are generally not accounted for in the definition of 'natural'.

'Natural' is less well defined for marine and freshwater, as human impacts may diffuse more broadly in water and be detectable farther afield, but with low impact, but the concept still applies (see Halpern et al. 2012, 2015, Jones et al. 2018). For rivers, a binary attribution of naturalness ('natural' vs. 'non-natural') is generally not used but there are several continuous indices which rate individual river reaches using criteria based on major pressures. One such index is the Connectivity Status Index (CSI; Grill et al. 2019). The index uses five major pressure types to score individual river reaches. Then entire river networks that score above 95 % for CSI for all reaches are defined as “free flowing rivers”. Based on this the world’s rivers have been assessed as “free flowing“ or “not free flowing”. For some this binary attribution is equivalent to natural vs. managed but this view is not universally adopted and there are major conceptual challenges in treating a river network as a single entity.

A clear definition of 'natural' is critical for the GBF for several reasons. First, too strict a definition of 'natural', for example restricted to 'wilderness', would mean that many countries would currently be classified as having little or no natural ecosystems. There are many ecosystems that have low human impact that make large contributions to biodiversity, but don’t meet the strict criteria of very low human influence and very large area used to define wilderness (Wintle et al. 2019, Riva & Fahrig 2022). Too broad a definition of 'natural' makes it possible to count low integrity ecosystems (e.g., low levels of biodiversity compared to relatively undisturbed ecosystems) towards conservation goals. Second, ‘natural’ is only used in Goal A (and Milestone A.1) and not other parts of the GBF, so a definition that clearly relates ‘natural’ ecosystems to other terminology in the GBF such as 'high integrity', ‘intact’ ecosystems and ‘wilderness’ would greatly facilitate the understanding of how actions across multiple targets contribute to the outcome in Goal A. Finally, net gains in natural ecosystem area and integrity (Goal A) cannot be calculated without a clear definition.

Suggestion:

- *A clear definition of ‘natural ecosystems’ in the GBF glossary including a more in-depth treatment of the gradient from highly natural to highly managed ecosystems could help avoid misunderstandings about the scope of Goal A and its relationship to targets, as well as greatly improve the ability to evaluate progress on the ecosystem area and integrity objectives of Goal A (see Glossary).*

1.b.ii) How are net gains in ‘natural’ ecosystem area calculated?

Net gains or losses in natural ecosystem area result from the balance between increases due to restoration of ‘transformed’ ecosystems to natural states and losses of existing natural ecosystems. 'Transformed’ ecosystems are defined as having been converted from natural areas to agricultural and other uses (IPBES 2018, see Glossary Appendix-Box 3). The definition of ‘transformed’ is similar, but not identical to the definitions of 'converted' (Strassburg et al. 2020) and ‘managed’ ecosystems (Díaz et al. 2020, see Glossary for extended discussion of terms). Increases in natural ecosystem area could also come from the restoration of natural ecosystems that are so badly degraded that they are no longer considered intact enough to be natural: in this brief we use the term ‘transformed’ broadly to include this case. It is important to note that many restoration actions do not create new area of natural ecosystems (see 1.b.iv).

Net change in natural ecosystem area in the context of the GBF can be written as follows (all increases and losses are expressed as ‘since 2020’ assuming that the reference reporting period is 2020):

Net change in natural ecosystem area =

Restoration of transformed to natural ecosystems

- Losses of natural ecosystems

Percent net gains or losses are then calculated based on the net gains in area divided by the total area of 'natural' ecosystems at the 'reference time period' and can be written as follows:

% Net change in natural ecosystem area =

100 x Net change in natural ecosystem area / Area of natural ecosystems in 2020

Examples of calculations of net change in global natural terrestrial ecosystem area are discussed in Section 2.b) for two scenarios: business-as-usual and a scenario that meets the objectives of 5% net gain by 2030 and 15% by 2050.

Suggestions:

- *Providing a clearer definition of 'net change in natural ecosystem area' in the GBF glossary, including its mathematical formulation, would help avoid confusion and make it possible to properly assess progress on Goal A.*
- *The relationship between Target 2 and the ecosystem area component of Goal A would be much clearer if Target 2 made explicit reference to the restoration of 'transformed' (or some other similar terminology such as 'converted') to 'natural' ecosystems.*

1.b.iii) Why is it important to have clear quantitative objectives for reducing loss of natural ecosystems?

No net loss and net gain goals often fail to conserve biodiversity when objectives for reducing losses are not explicit, and the lack of explicit objectives to halt losses of natural ecosystems is a major weakness of the wording of the first draft of the GBF (Díaz et al. 2020, Maron et al. 2021). First, it is important to prioritise slowing losses of existing, in part because newly restored 'natural' ecosystems often take decades or centuries to reach high levels of integrity if ever (Maron et al. 2021, Milner-Gulland et al. 2021, Atkinson et al. 2022, Leadley et al. 2022, CBD/WG2020/3/INF/11). The priorities for protecting and restoring biodiversity should be 1) avoid losses, 2) minimise losses, 3) restore and 4) offset losses in other places (Milner-Gulland et al. 2021). Second, some loss of natural ecosystems over the coming decades is inevitable. But there are ecosystems that are so rare, unique or threatened that halting losses is essential: these have been termed 'critical' and 'irreplaceable' (Díaz et al. 2020, Maron et al. 2021, Milner-Gulland et al. 2021). Third, Target 1 only refers to 'retaining existing intact and wilderness areas'. It is not clear what 'retaining' means in terms of reducing losses. And reducing losses in 'intact and wilderness areas' is very important, but by most definitions of these terms only covers a fraction of losses in natural ecosystems.

Target 2, as worded in the first draft of the GBF, has a number of serious weaknesses because it: i) does not refer to retaining natural ecosystems other than 'intact ecosystems' and 'wilderness', ii) is unclear what 'retaining' implies in terms of reducing losses, and iii) does not address the need to halt losses of 'critical' ecosystems.

Suggestions:

- *Setting a clear objective for halting losses in critical ecosystems and significantly reducing losses in natural ecosystems (as was the case for Aichi Target 5) in Target 1 or in Goal A could help avoid the pitfalls of 'net gain' framing of Goal A.*

1.b.iv) How does restoration contribute to increasing natural ecosystem area?

Restoration is often used quite broadly to refer to actions that aim to enhance composition or structure or nature's contributions to people (NCP) components of ecosystem condition in terrestrial, freshwater or marine ecosystems (IPBES 2018, Duarte et al. 2020, UNCCD 2022, Glossary Appendix-Box 3). Many actions referred to as 'restoration' use this very broad definition, for example many forest restoration actions in the Bonn Challenge, do not increase the area of natural ecosystems and in some cases do little to increase ecosystem integrity. Indeed, substantially less than half of the Bonn Challenge commitments should probably be counted towards restoring natural ecosystem area (IPBES 2018, Gann et al. 2019, Secretariat of the Convention on Biological Diversity 2020, UNCCD 2022).

Restoration increases natural ecosystem area only when 'converted' or 'transformed' ecosystems are restored to states that are similar in integrity to 'natural' reference ecosystems—which is an ecosystem in a similar environment that has low human impacts (IPBES 2018, Gann et al. 2019, Glossary Appendix-Box 3). Examples of restoration outcomes that do not increase natural ecosystem area include: 1) Restoration that increases the biodiversity and NCP of agricultural ecosystems (sometimes referred to as 'regeneration' or 'rehabilitation', IPBES 2018, Gann et al. 2019); 2) restoration that creates systems that don't have sufficient integrity to be considered natural, such as forest plantations, especially monospecific stands with alien species (these actions are sometimes referred to as 'regeneration' and can contribute little to ecosystem integrity, Chazdon 2008, Gann et al. 2019, Löf et al. 2019); and 3) restoration to new systems that may have high diversity and NCP value, but are not like a 'natural' reference system (UNCCD 2022). Examples that do increase the area of natural ecosystems include restoration of abandoned cropland to a forest that is similar to surrounding 'natural forests' (Glossary Appendix-Box 3, IPBES 2018, Gann et al. 2019).

To be successful in compensating for losses in natural ecosystem area, restoration should focus on replacing destroyed or badly degraded natural ecosystems with a similar ecosystem type, using a relatively fine level of definition of ecosystem type. For example, simply compensating 'forest' loss with 'forest' restoration provides little guarantee that deforestation of high integrity forests is compensated by anything other than low integrity tree monocultures. These principals are often collectively referred to as like-for-like compensation (Díaz et al. 2020, Maron et al. 2021).

Because Target 2 in the first order draft of the GBF does not specify the objective of restoration actions, it provides no guidance on how Target 2 should be implemented, nor how it contributes to gains in natural ecosystem area. Implemented without sufficient guidelines Target 2 could potentially make little contribution to increasing natural ecosystem area and only modest contributions to ecosystem integrity.

Suggestions:

- *Target 2 would be clearer and easier to relate to Goal A if it had separate objectives for restoration of degraded ecosystems to increase integrity (which may or may not ecosystem area, see Section 1.c.iv) and restoration of <u>transformed</u> to <u>natural</u> ecosystems which increases the area of natural ecosystems.*
- *Including clear wording on strict like-for-like compensation in Target 2 could also help avoid the pitfalls of 'net gain' framing of Goal A.*
- *Expressing restoration of transformed to natural terrestrial ecosystem objectives in terms of global area (millions of hectares, Mha) would avoid known issues with defining the current extent of 'transformed' or 'converted' area. This would make it much easier to quantify objectives and progress for terrestrial ecosystems. Area-based objectives for restoration would need to be different for freshwater and marine ecosystems, and are poorly adapted to freshwater and marine ecosystems where area is not a good measure of restoration objectives.*

1.b.v) How do 'intact and wilderness areas' referred to in Target 1 relate to 'natural ecosystems' in Goal A? How could Target 1 and Goal A be reworded to improve coherence?

Intact ecosystems and wilderness areas are very closely associated terms and are to a large extent redundant, and often used as synonyms of ecosystems with very high integrity (see Glossary). These are generally defined with stricter limits on low human influence and minimal area requirements than for 'natural' ecosystems, such that only half or less of 'natural' ecosystems are generally considered 'wilderness' (see Glossary). As such, Target 1 only refers to retaining a subset of 'natural' ecosystems, creating a disconnect between wording of Target 1 and Goal A. Many ecosystems that are not wilderness should be high priority for halting losses and should therefore be explicitly addressed in Target 1 (Díaz et al. 2020 used 'critical' ecosystems, and Maron et al. 2021 used 'irreplaceable' to refer to these systems).

Suggestions:

- *Rewording Target 1 to be more inclusive than 'intact and wilderness areas' would make it clearer that Target 1 has the objective of reducing losses in the area of all natural ecosystems. This would clarify links with Goal A.*
- *It is important to distinguish between ecosystems, typically referred to as 'critical' or 'irreplaceable' where it is essential to halt losses immediately, and other 'natural' ecosystems where losses should be greatly reduced, but cannot realistically be brought to zero by 2030.*

1.b.vi) What are the roles of protected areas and other effective area-based conservation measures (OECM) in Target 3 in contributing to net gains in natural ecosystem area?

Protected areas, when properly resourced and managed, and OECMs reduce losses of natural ecosystem area (see Target 3 brief). As such, protected areas are one of the keystones of biodiversity-inclusive spatial planning (see Section 1.d).

1.b.vii) What is an ambitious and feasible quantitative global objective for net gain in natural ecosystem area? How do global quantitative objectives translate to national levels?

For land, about 350-400 Mha of restoration of transformed to natural ecosystems globally along with substantial reductions in losses of natural ecosystems are very ambitious objectives, but are needed to attain a 5% increase in natural ecosystem area by 2030 (see Section 2b). This might seem coherent with the Bonn Challenge of 350 Mha of forest restoration by 2030, but it is much more ambitious because about half of Bonn Challenge is low diversity forest plantations and should not be counted as natural (Secretariat of the Convention on Biological Diversity 2020, UNCCD 2022). The means of achieving this in terms of the transformative changes required is addressed in Section 2b of this brief based on a synthesis of global 'bending the curve'' scenarios. Clarifying this will help countries plan and implement their restoration efforts. Similar calculations are not available for marine and freshwater ecosystems, but it should be possible to do these same calculations for marine and freshwater ecosystems where natural ecosystem area is an appropriate measure of biodiversity conservation and restoration objectives. Global objectives, especially quantitative objectives should not be translated directly to national levels because this would result in sub-optimal use of resources and outcomes for nature and people. While quantitative objectives expressed as percent might appear to be easier to translate from global to national levels than global area, we illustrate in Section 2c why this is not the case. Section 2c addresses this in depth and illustrates how area-based objectives could be interpreted and implemented at national levels.

1.c) Integrity of all ecosystems, including the integrity of natural ecosystems

1.c.i) What does ecosystem integrity mean? Why is it important to the GBF?

Ecosystem integrity is a measure of ecosystem structure, function and composition relative to the reference state of these components, typically an intact ecosystem in a similar environment (Noss 1990, Teixeira et al. 2016, Nicholson et al. 2021, Karr et al. 2022, see Glossary). Ecosystem integrity is a highly relevant measure of the progress resulting from actions in targets (Karr et al. 2022), and in particular for Target 1 in which the objective of retention of remaining ecosystems focuses on those with high integrity; Target 2 for which it is an important measure of the need for restoration and success in restoration; Target 3 for which it indicates if protected areas are effectively managed and Target 10 for which it indicates if agriculture, aquaculture and forestry are managed sustainably (Garibaldi et al. 2020). It should be noted that the term ‘integrity’ is not widely applied to managed ecosystems other than forests; for example ‘ecosystem health’ and ‘ecosystem condition’ are more commonly used and widely accepted for agricultural ecosystems (Roche & Campagne 2017) and in marine ecosystems (Halpern 2020). Ecosystem integrity is, however, used at landscape levels that include a wide range of agricultural and other transformed ecosystems and achieving 100% of the composition, structure and function of intact natural ecosystems is typically not the reference used to assess high levels of integrity (McGarigal et al. 2018, Walston & Hartmann 2018, DeClerck et al. 2021, Zelený et al. 2021).

Suggestion:

- *Maintaining ‘integrity’ in the wording of GBF is important because it is much more inclusive than wording focusing on less than all three components of integrity: composition, structure and ecosystem function.*

1.c.ii) How do you measure ecosystem integrity?

There is general agreement that ecosystem integrity includes components of ecosystem structure, function and composition (Díaz et al. 2020, Hansen et al. 2021, Nicholson et al. 2021). There is, however, no common agreement on the individual indicators for each of these components, nor their respective weights. This situation is evolving rapidly, and the concept, means of monitoring, and demonstrated applications of ecosystem integrity are well developed for some types of ecosystems such as forests (Hansen et al. 2021, Nicholson et al. 2021, Background Appendix-Figure 1). Indicators of the components of ecosystem integrity are now available for application for many ecosystems and can be applied for the GBF (Hansen et al. 2021, Background Appendix-Table 1). These can be combined into an overall ecosystem integrity index and used as a headline indicator for some ecosystems (Hansen et al. 2021, Background Appendix-Table 1).

Commonly used indices that measure biodiversity intactness compared to reference intact ecosystems such as mean species abundance (MSA, Schipper et al. 2020) and biodiversity intactness indexes (BII, e.g., Newbold et al. 2015) are often used as proxies of integrity, but these indicators only measure part of the compositional component of integrity, and are not necessarily good indicators of ecosystem integrity / condition / health of managed ecosystems because they are based on reference states of natural ecosystems (Roche & Campagne 2017, DeClerck et al. 2021).

Suggestions:

- *Reach agreement on the definition of ecological integrity for GBF Glossary and monitoring framework.*
- *Think about how to express 'integrity' of managed ecosystems and landscapes, especially for semi-natural ecosystems.*
- *Think through how to measure and express 'integrity' in the most meaningful way in marine and freshwater ecosystems.*
- *Apply multiple indicators that are adapted to ecosystem types.*

1.c.iii) How are net gains in natural ecosystem integrity calculated?

Net change in natural ecosystem integrity can be written as follows (all increases and losses expressed as 'since 2020' assuming that the reference reporting period is 2020):

Net change in natural ecosystem integrity =

Increases in integrity from restoration of existing natural ecosystems

+/- Increases/losses in integrity resulting from restoration of transformed to natural

+/- Increases/losses in integrity from alleviation of / increases in pressures in natural

- Losses of integrity due to transformation of natural ecosystems

This formula is more complex when including managed landscapes or seascapes, but there are attempts underway to do this calculation for global terrestrial ecosystems (DeClerck et al. 2021). Percent net gains or losses are then calculated based on the net gains in area divided by the total area of 'natural' ecosystems at the 'reference time period' and can be written as follows:

% Net change in natural ecosystem integrity =

100 x Net change in natural ecosystem integrity /

Integrity of natural ecosystems in 2020

Suggestions:

- *Providing a clearer definition of 'net change in natural ecosystem integrity' in the GBF glossary, including its mathematical formulation, would help avoid confusion and make it possible to properly assess progress on Goal A.*

1.c.iv) How does restoration of 'degraded' ecosystems contribute to ecosystem integrity? Should restoration be explicitly qualified in Target 2 wording to specify an objective of increased integrity?

Expressing restoration as a percentage of 'degraded' ecosystems is very problematic. In part, this is because degradation can be a continuous process and there is no consensus on when a threshold is passed to constitute "a degraded ecosystem". In addition, the notion of what is degraded is highly value laden and a very wide range of indicators is used to measure degradation (IPBES 2018, IPCC 2019, UNCCD 2022). For example, the Global Land Outlook 2 (UNCCD 2022) gives a range of 20-40% of global land that is degraded, where the upper bound includes nearly all agricultural land. This makes assessment of objectives based on percent restoration of degraded lands exceptionally problematic. For example, percent restoration of degraded ecosystems was not used for assessment of progress towards Aichi Target 15 in the Global Biodiversity Outlook 4 (Leadley et al. 2014), nor in the Global Biodiversity Outlook 5 (Secretariat of the Convention on Biological Diversity 2020). There is no simple solution to this, since decades of research and international negotiations have not reached agreement on a definition of degraded that would allow Target 2 to be clearly quantified as it is currently worded. International assessments and reports such as the IPBES Land Degradation and Restoration Assessment (IPBES 2018), the Global Biodiversity Outlook 5 (Secretariat of the Convention on Biological Diversity 2020) and the Global Land Outlook 2 (UNCCD 2022) have typically evaluated global restoration actions and commitments in numbers and types of projects, or area rather than percent restoration of degraded area. The most ambitious international commitment for restoration, the Bonn Challenge, is expressed as a global area of 350 Mha of forest to be restored. The UNCCD has set objectives of land degradation neutrality and Zero Net Land Degradation. These are problematic in terms of evaluation of progress, in part because of issues related to like-for-like compensation.

Marine restoration attempts have had varied and unpredictable success (Fraschetti et al. 2021), with poorer outcomes in offshore and open ocean areas (Elliott et al. 2007). Prioritisation of sites according to human use and conservation status will achieve greater biodiversity benefits (Fraschetti et al. 2021) and direction of effort into alleviation of pressures on offshore marine ecosystems is likely to be more beneficial to marine biodiversity than restoration efforts in these areas (Elliott et al. 2007) much recent emphasis is being placed on undertaking Integrated Ecosystem Assessments (Levin et al. 2014) to assist in identification of mitigation measures along most impactful sector-pressure-ecological pathways.

Suggestions:

- *Providing a typology of restoration actions in GBF glossary and explaining how they are related to goals and targets would help clarify the objectives of restoration in the GBF, their implementation, monitoring and assessment of progress.*
- *Explicitly stating in Target 2 that it focuses on restoration that aims to increase ecosystem integrity would highlight the importance of restoration actions that contribute to Goal A and discount restoration actions that contribute little to Goal A.*

1.c.v) What are ambitious and feasible quantitative global objectives for net gain in ecosystem integrity? How do global quantitative objectives translate to national levels?

Global ecosystem integrity is much more difficult to calculate than ecosystem area because of the additional complexity in its formulation (see 1.c.iii) and the lack of integrity indicators for many ecosystems (see 1.c.ii). Therefore, all analyses of changes in future global scale integrity should be viewed with considerable caution. In the analysis of global scenarios in CBD/WG2020/3/INF/11 we wrote concerning the 'bending-the-curve' scenarios analysed by Leclère et al. (2020) that “Taken together, these actions are projected to contribute substantially to achieving a global net gain in the area of ecosystems by 2030 (area component of Milestone A.1), and a stabilisation (but not reversal) of species distribution, population and extinction rate (so making progress towards but not fully attaining Milestone A.2 objectives of early 'bending-the-curve'; Figure 1.3). Time lags involved in biodiversity recovery (see Message 2 and Technical Section 2) reduce the likelihood of achieving ambitious outcomes for species and ecosystem integrity (as compared to ecosystem area outcomes) in 2030 milestones A.1 and A.2 and parts of the 2050 Goal A (implying strong recovery, beyond ecosystem extent).”

Other scenarios analysed in CBD/WG2020/3/INF/1 are in agreement with this analysis of Leclère et al. (2020). Based on these analyses of integrated assessment models (IAMs), a no net loss of ecosystem integrity objective by 2030 would seem ambitious and a 5% gain exceptionally difficult (see also Díaz et al. 2020). However, the IAMs used for these scenarios overlook many important aspects of integrity that may make them overly pessimistic. First, the analyses were based entirely on the composition component of integrity, and some structural and functional components may recover more quickly than compositional components. Second, the ability of IAMs to account for restoration actions is limited and focus on restoration of transformed to natural ecosystems (CBD/WG2020/3/INF/1): other restoration actions could also make major contributions to integrity (see 1.c.iii).

1.d) Spatial planning

1.d.i) What is ‘biodiversity-inclusive’ spatial planning? Why is it important for the GBF?

Biodiversity-inclusive spatial planning everywhere is important because it addresses loss and degradation of biodiversity both outside and inside protected areas. Areas outside protected areas are critical for the conservation of biodiversity—and for nature's contributions to people—because a large fraction of the world's biodiversity will only be found there even with 30% protected area coverage (Locke et al. 2019, Riva & Fahrig 2022). The situation is likely more extreme in the case of marine ecosystems, given that 75% of Exclusive Economic Zones have less than 10% of their geomorphic features and benthic habitats protected (Fischer et al. 2019).

For the GBF, Target 1 provides a spatial context for integrating all the other targets—particularly the area or ecosystem-based Targets 1, 2, 3 and 10 (Background Appendix-Figure 2), but also the targets/goal relating to the integrity of biodiversity (Background Appendix-Figure 2), sustainable use (targets 9-13), spatial aspects of tools and solutions (Targets 14-20) and, very importantly, the rights and responsibilities of IPLC and other stakeholders (Target 21). For example, integrated spatial planning is necessary to ensure that two components of Target 3 are met, specifically ''ecologically representative, well-connected systems of protected areas [...] integrated into the wider landscapes and seascapes''. Indeed, integrated spatial planning is the mechanism through which authorities can maintain or restore sufficient connectivity within and across protected areas, and mitigate pressures to biodiversity in the wider landscapes and seascapes, while representation is one of the core principles of spatial conservation planning theory and tools (Margules & Pressey 2000, Wilson & Piper 2010, Kukkala & Moilanen 2013). Similarly, opportunities for habitat restoration are increased by reducing pressures on land through integrated planning (Leclère et al. 2020, Williams et al. 2020), and restoration success is improved by mitigating pressures outside restoration areas.

1.d.ii) How does spatial planning contribute to reducing the loss of biodiversity?

Evidence of the benefits of integrated land use planning in promoting synergies between multiple development goals abound and include the social, environmental and economic benefit of integrated coastal management in Belize (Arkema et al. 2015) and Australia (Ban et al. 2015), integrated forest management in Europe (Sotirov & Arts 2018). Local, empirical evidence has also been used to parameterize models to estimate the maximum potential of integrated planning in the oceans (Sala et al. 2021) and on land (Fastré et al. 2021).

Without Target 1, goal A will be missed even if Targets 2 (on ecosystem restoration) and 3 (on protected areas) are met. Critical ecosystems, their unique biodiversity, and their contributions to people will be irrevocably lost due to ongoing land-/sea-use change (Díaz et al. 2020). The loss and degradation of natural habitats outside protected and restored areas will reduce biodiversity and many classes of NCP across most of the world (Brauman et al. 2020). Even within protected areas, biodiversity will decline as the surroundings become less nature-friendly (Laurance et al. 2012, Díaz et al. 2020, Leclère et al. 2020, Maxwell et al. 2020, Fastré et al. 2021, Leadley et al. 2022).

Spatial planning does not, however, guarantee positive outcomes for biodiversity per se, for two reasons. First, other factors may override biodiversity, such that all the feasible expected outcomes involve some overall loss of biodiversity (CBD/WG2020/3/INF/11). Second, plans may fail to deliver their expected outcome. Plans are more likely to succeed if they are developed inclusively with local actors and stakeholders, consider biodiversity processes as well as patterns, are resourced adequately, and have strong and transparent governance (OECD 2017, CBD/WG2020/3/INF/11). There are many examples of failures as well as successes that should be learned from OECD (2017).

1.d.iii) How does spatial planning contribute to meeting a wide range of SDG objectives?

Target 1 requires inclusion of biodiversity in spatial planning everywhere, while recognizing that biodiversity is not the only factor to be considered when making decisions. Including biodiversity in spatial planning can improve outcomes for both nature and livelihoods. Planning that considers multiple dimensions can find solutions that, while not optimal for any single dimension, score highly on them all (Strassburg et al. 2020, Jung et al. 2021).

1.d.iv) Is it feasible to do spatial planning everywhere by 2030?

Most places have some form of spatial planning (Metternicht 2018). But the fraction that could be considered biodiversity-inclusive is not well known, in many places being limited or non-existent in many places (Metternicht 2018). The feasibility of achieving biodiversity-inclusive spatial planning in 100% of all land and sea areas is not well known. Many countries currently lack the capacity to include biodiversity in spatial planning by 2030, so substantial resources would have to be rapidly mobilised, and new partnerships facilitated, to build human and technical capacity. Many countries indicated they lack the capacity to do this (CBD/WG2020/4/INF/1), but all countries have planning processes that cover nearly all of their terrestrial land and freshwater. Marine spatial planning is underway in over 100 countries around the world (UNESCO-IOC/FAO 2022), estimated to account for at least 44% of nations with marine waters (Frazão Santos et al. 2019), but it is a strong aspiration and science-based target for full coverage to be achieved in the near future.

1.d.v) How can progress on spatial planning be measured?

The current list of indicators in the GBF monitoring framework focus on the extent to which spatial planning considers biodiversity, but not the quality of the spatial planning, in other words, whether these plans are effectively designed to i) abate the threat of land/sea-use change, and ii) contribute to the achievement of goals A, B, C within the respective jurisdictions. A state variable indicator, such as the expected changes in the STAR metric (Mair et al. 2021) or the Red List of Ecosystems (Bland et al. 2018, Rowland et al. 2020) attributable to area-based conservation would be best placed to complement the current list of response variable indicators. There are multiple indicators that quantify land/sea-use change (e.g., Human Footprint), and its predicted/modelled impacts on biodiversity (e.g., Biodiversity Intactness Index, Biodiversity Habitat Index), as well as forest loss/cover change (Curtis & Larson 2020, Global Forest Watch, Global Mangrove Watch).

1.d.vi) Why is it important to take into consideration the IPLC roles, rights, and equity in Target 1?

A key concern for many countries and stakeholders is that spatial planning is conducted with full acknowledgement of the rights and participation of Indigenous People and Local Communities (IPLC), and of other stakeholders. Lands managed by IPLC have, on average, better biodiversity status and trends than other land (IPBES 2019). Almost half of the text proposals from Geneva addresses these issues: [and the places most important for delivering ecosystem services/nature's contributions to people]], [sustaining ecosystem services, …]/[and taking into account [and respecting] [, in the context of sustainable development and poverty eradication,] the customary rights of Indigenous Peoples and local communities.].

<u>1.e) Suggestions for rewording of Goal A, Target 1 and Target 2</u>

The considerations in sections 1.b-d above support the rewording of Goal A, Target 1 and Target 2. An example shows how the wording and quantitative objectives could be improved to explicitly link Goal A, Target 1 and Target 2, without intending to be prescriptive. For terrestrial ecosystem area in particular this brief shows how Target 1 and Target 2 quantitative objectives can be aligned to match objectives for Goal A and vice versa. Changes in text compared to the first draft of the GBF are indicated in <u>underlined text</u>.

Goal A (Ecosystem objectives): The integrity of all ecosystems is enhanced, with an increase in the area, connectivity and integrity of natural ecosystems <u>by *X%*</u> *by 2030* and <u>*X%*</u> by 2050.

Suggestions:

- *Few changes compared with the GBF first draft wording: the only change is that the 2030 Milestone A.1 has been incorporated in the wording of Goal A.*
- *The analyses in sections 1a-d suggest that 5% net gain in area by 2030 and integrity of natural terrestrial ecosystems and 15% by 2050 is feasible—but these are very ambitious and would require deep, systemic changes in production and consumption.*
- *It would be helpful to clarify in the glossary than 'natural' = 'high integrity' ecosystems*

Target 1 (option 1): Ensure that all land and sea areas globally are under integrated biodiversity-inclusive spatial planning <u>that includes the objectives of halting the loss and degradation of critical ecosystems, substantially reducing the loss and degradation of wilderness and other natural ecosystems, and reconciling competing demands for land and marine resources</u>.

Target 1 (option 2): Ensure that all land and sea areas globally are under integrated biodiversity-inclusive spatial planning that includes the objectives of bringing the rate of loss and degradation of high integrity ecosystems as close to zero as possible, and reconciling competing demands for land and marine resources.

Suggestions:

- *Clarifies the dual objectives of spatial planning which are to greatly reduce losses of biodiversity and reconcile this with other uses of land and sea*
- *Employs terminology that makes it easier to make direct links with Goal A by including an objective (albeit non-quantitative) for reducing losses of wilderness and all natural ecosystems (or high integrity ecosystems)*
- *Clearly states the objective of halting the loss of critical ecosystems (option 1), but could perhaps be specified elsewhere.*
- *The second option uses fewer words and has a clearer loss reduction ambition than option 1 by: i) Using 'high integrity ecosystems' or similar wording in place of 'wilderness and other natural ecosystems'. This would simplify wording and help avoid terminology that is contested. ii) Setting an aspirational goal of bringing losses as close to zero as possible by 2030 (similar to Aichi Target 5). This is the scenario presented in Section 2b that achieves 5% net gain of ecosystem area by 2030.*

Target 2: Ensure that a substantial fraction of degraded freshwater, marine and terrestrial ecosystems are under restoration actions to increase ecosystem integrity, ensuring connectivity, like-for-like compensation of losses of natural ecosystems, and at least *X* Mha of restoration of transformed to natural terrestrial ecosystems globally.

Suggestions:

- *Includes a non-quantitative objective for overall restoration efforts for degraded ecosystems because i) there is no commonly agreed upon quantitative value for degraded systems in any of the three realms and ii) that any quantitative value would likely differ between freshwater, marine and terrestrial ecosystems.*
- *Analyses in Section 2 of this brief suggest that 350-400 Mha of restoration of transformed to natural terrestrial ecosystems is feasible and needed to meet the objective of 5% net gain of natural ecosystem area by 2030.*
- *This wording adds the important condition of like-for-like compensation and specifies the total amount of land area to be restored from converted to natural areas in order to achieve the natural ecosystem areas objectives of Goal A. This is wording highly desirable, but could perhaps be specified outside of target wording.*
- *Note that the restoration of converted land objective is probably better expressed as a global area objective, since the extent of converted land is not well bounded.*

2) Quantitative and qualitative analysis of ecosystem area objectives

2.a) Overview of natural ecosystem area in goals and targets

The change in the area of natural ecosystems (Goal A) represents a balance between reducing losses of natural ecosystems (Target 1b) and restoring transformed ecosystems and badly degraded natural ecosystems to a more natural state (Target 2).

2.b) Global analysis of natural ecosystem area objectives

Figure 1 presents calculations for terrestrial ecosystem area for two scenarios: 1) the first scenario meets the objectives of 5% net gain by 2030 and 15% net gain by 2050 set in the first draft of the GBF and 2) the second scenario represents a continuation of current rates of losses of natural ecosystems combined with ambitious, but not exceptionally ambitious restoration. These scenarios are intended to give a sense of the ambition that is needed to meet the 2030 and 2050 objectives for net gain in area of natural terrestrial ecosystems and provide an illustration of how, with judicious rewording, the objectives in Goal A can be quantitatively related to Target 1 (and by extension Target 3) and Target 2. The feasibility and means of achieving these goals and targets are then discussed in the context of much more sophisticated global scale "bending-the-curve" scenarios and other evidence. The need for clearer definitions and greater coherence in the wording in Goal A and Targets 1 and 2 is also discussed. Finally, we suggest ways in which the same methods could be applied to marine ecosystems.

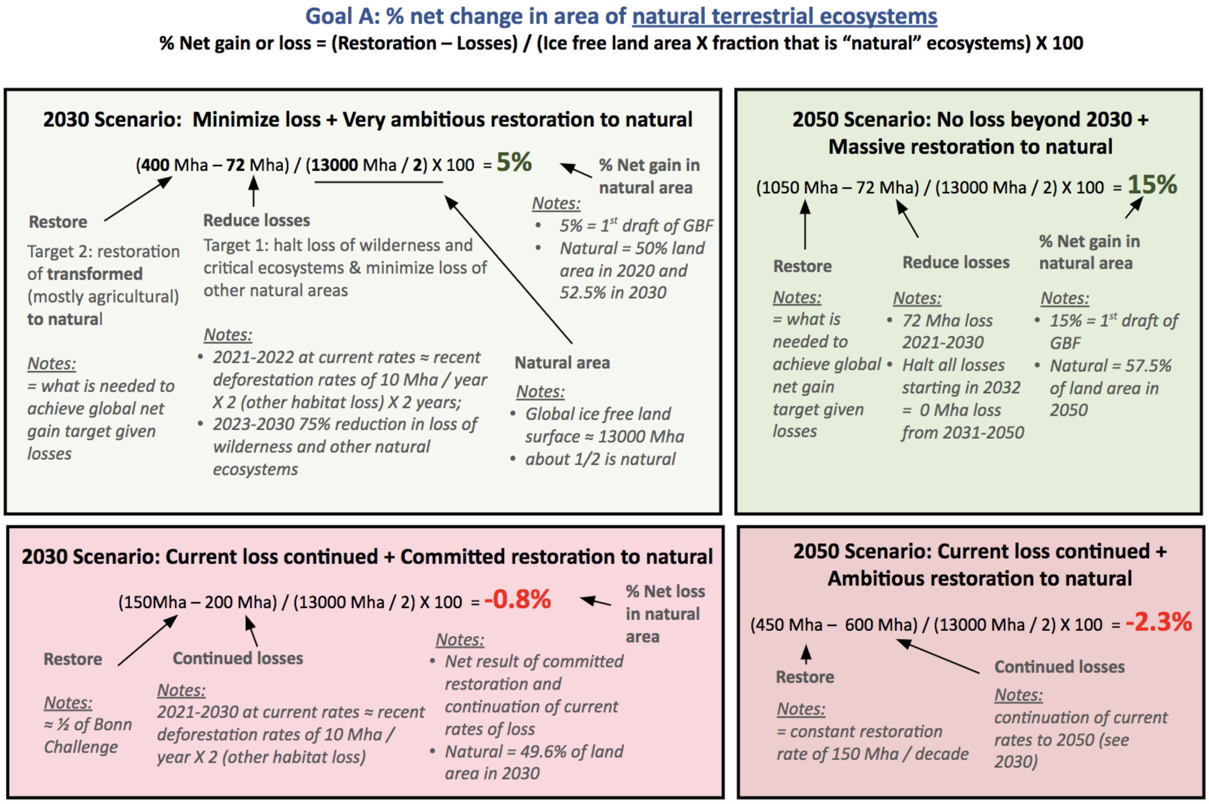

Figure 1. Simple global scale calculations of net change in the area of natural terrestrial ecosystems. *The upper panels are scenarios that meet numerical targets for 2030 and 2050 set in Goal A of the GBF. The lower panels are "business-as-usual" scenarios. These scenarios are based on simple assumptions concerning current natural area, rates of losses of natural areas (Target 1 and by extension Target 3) and restoration of transformed lands to natural ecosystems (Target 2). A 75% average reduction in losses over the period 2023-2030 is the equivalent of ramping up to a 100% reduction (i.e., halting losses) by 2027. Key assumptions are noted in the figure; justification for these assumptions can be found in Background Appendix-Box 1. Note that wording for Targets 1 and 2 reflect suggested modifications of wording compared to the first draft of the GBF (see text). For an idea of scale, the area of China is about 960 Mha and Kenya 58 Mha. 1 Mha = 10 000 km^2. The reference year for calculating net gain or loss is 2020.*

Main messages from the simple scenarios in Figure 1

- It appears feasible to meet the quantitative objectives set for net gain in natural terrestrial ecosystem area in Goal A, but these calculations highlight the importance of very high ambition: actions that greatly reduce losses of natural ecosystems and exceptionally ambitious restoration of transformed to natural ecosystems are required to meet the 2030 and 2050 objectives.
- Business-as-usual losses, even with ambitious restoration of transformed to natural ecosystems, result in net loss of natural ecosystem area by 2030 and 2050.
- By 2030 (and even by 2050) areas under restoration will be in early stages of restoration far from a "natural" status that often takes decades or centuries to reach. So this increase in area does not mean that the integrity components of Goal A will be met (CBD/WG2020/3/INF/11, Leadley et al. 2022).

This also means that reductions of losses play a relatively smaller role in net changes in area than they do for integrity.

- Achieving the numerical objectives of net gain proposed in the first draft of the GBF is dominated by very ambitious restoration; reductions in losses play a relatively smaller role. This could lead to perverse incentives to focus on restoration rather than slowing losses as has occurred in the majority of cases of net gain/loss targets. This argues in favour of a clear numerical objective for reducing losses in Target 1 or in Goal A (Díaz et al. 2020). Restoration does not have the opportunity to compensate for the loss of integrity of old ecosystems that are lost, which is a compelling reason to focus on reducing losses.
- Natural area is the denominator of the calculation of net change in natural area, so choosing a very low natural area (e.g., just wilderness area) makes it much easier to achieve the objective of large net gains, but fails to address large areas that are natural. This could lead to perverse incentives to use overly strict definitions of "natural" ecosystems when assessing progress towards this goal.
- Restoration of transformed ecosystems to natural ecosystems takes land out of agricultural production. While many of these lands might be marginally productive, the loss of agricultural production would need to be compensated for by increased production elsewhere and/or more sustainable diets and reductions in food waste.

Feasibility, relationship to SDGs, and means of achieving net gains in natural ecosystem area

Comparisons of these simple scenarios with those made with more sophisticated scenario analyses with Integrated Assessment Models (IAMs) helps to provide insight into the feasibility, relationship to SDGs, and means of achieving the ambitious objectives in Figure 1. We summarise the analysis of 'bending-the-curve' for biodiversity scenarios from the "Expert Input" information document prepared in support of the negotiations of the GBF in Geneva, March 2022 (see CBD/WG2020/3/INF/11 for details, tables and figures numbers prefixed by "EI" in the summary below are references to this "Expert Input" information document, see also Leadley et al. 2022).

- Holding losses to only 72 Mha in the 15% net gain scenario for 2050 is very ambitious compared to losses in 'bending-the-curve' scenarios. Estimates of losses from global scenarios vary widely: the lower end estimates of gross conversions natural ecosystems to agriculture and forestry between 2020 and 2050 are about 400-550 Mha in 'business-as-usual' (Kok et al. 2020, Leclère et al. 2020, EI Table A1.3.1-Appendix 1.3), ranging up to over 1200 Mha (Strassburg et al. 2020, Fastré et al. 2021). In the best scenarios, losses are estimated to be around 200 Mha over this same period (EI Table A1.3.1-Appendix 1.3). The 72 Mha loss by 2030 is also low (EI Table A1.3.1-Appendix 1.3). Using these best case losses from 'bending-the-curve' scenarios would require substantially more ambitious restoration: about 1200 Mha. Strassburg et al. (2020) tested a scenario 55% restoration of transformed to natural ecosystems (=1580 Mha). Such large scale restoration may only be possible through transformative changes in our food system, reducing over-consumption, food waste and changes in dietary composition, and necessitate strong safeguards to avoid risks for livelihoods and food security. The 2050 restoration assumption (1050 Mha) is roughly equivalent to the highest values used by Leclère et al. (2020) and Kok et al. (2021) in terms of absolute area (around 1000 Mha, see Table A.1.3.1 in info doc).
- Overall, 'bending-the-curve' scenarios project a net gain in natural ecosystems generally fall below the 15% net gain in natural terrestrial ecosystems from 2020 to 2050, with middle ground of about 10% a range of -1% to 20% (assuming land is currently about one-half natural ecosystems), but well above the "business-as-usual" scenario (EI Appendix 1.3-Table A1.3.1). This suggests that 15% is exceptionally ambitious based on what is assumed in these scenarios, but appears to be feasible under certain conditions in a context of achieving multiple SDGs simultaneously.
- All of the analyses with integrated assessment models (IAMs) used in the analyses in CBD/WG2020/3/INF/11 (see also Leadley et al. 2022), include considerable improvements in most aspects of NCP and human well-being. One of the most recent of these analyses shows that achieving a wide range of SDGs related to human well-being and those related to the environment have very strong synergies (Soergel et al. 2021). One clear example of this is related to food systems. Greatly reducing food waste and overconsumption improves food security (assuming equitable

sharing of the benefits of these actions), makes a substantial contribution to climate mitigation, reduces pollution and greatly diminishes pressures on biodiversity.

Reducing loss of natural area is extremely important, it requires transformative changes to our food system and limiting reliance on biofuels for achieving the energy transition in order to decrease pressure of expansion of agricultural lands (IPBES 2018, 2019). At the same time, there are many areas where progress can be made to closing yield gaps through sustainable intensification, again lowering demands and thus reducing losses (IPBES 2019, FAO & INRAE 2020).

Restoration may be difficult and face trade-offs in areas transformed to highly productive agricultural and residential land systems. Most potential for restoration of transformed to natural ecosystems is found in areas that have been converted from natural areas, but have marginal yields or have faced degradation through previous use (UNCCD 2022). Such areas include agricultural abandonment areas that provide considerable potential for re-wilding, but also include areas transformed for extensive cultivation or grazing, with low productivity, but sometimes harmful impacts on fragile ecosystems (IPBES 2018, UNCCD 2022). In restoring those areas care should be taken of the reliance of local communities on these lands and the land rights they hold. Spatial planning and sustainable intensification in these systems may free up a lot of land in these areas, creating shared landscapes in which both nature and people benefit from the restoration activities (Obura et al. 2021).

<u>Implications for the wording of Goal A, Target 1 and Target 2</u>

- Goal A - provide a much clearer definition of natural in GBF glossary.
- Target 1 - set specific objectives concerning reducing losses of critical ecosystems, as well as other natural ecosystems.
- Target 2 - set specific objectives for restoration of <u>transformed</u> to <u>natural</u> ecosystems which should not be conflated with general wording concerning restoration of degraded ecosystems. We suggest using a global area (millions of hectares) target for this rather than a percent because of large ranges in the estimates of transformed land available for restoration to natural ecosystems.

<u>Application to marine and freshwater ecosystems</u>

We have not applied these calculations to marine and freshwater ecosystems, because their dynamics are somewhat different, but also because datasets on ‘natural area’ are less well established. For some specific freshwater and marine systems this could be relatively easily done, because the data is available to make at least rough calculations (e.g., wetlands, UNESCO-IOC/FAO 2022). The overall principles may be similar, though practical application of actions to achieve target levels may be very different.

2.c) Translating global objectives for net gain in natural ecosystem area to national levels

Translation to national levels of the global scale numerical elements of Goal A and Targets 1, 2, 3 and 10 (to address the overall transitions between natural, managed (used broadly to include transformed and converted areas, see glossary) and restored areas requires taking into account national contexts. We show visual illustrations of hypothetical countries with varying proportions of land categories in the GBF, to illustrate the global calculations above. The global average illustrates the near 50/50 split between managed and natural/semi-natural landscapes, protected/conserved areas at 17% (Aichi Target 11 in 2020), and the proportion of degraded lands (15.8%) across semi-natural and managed lands (Figure 2). In 2030 (right panel) restoration actions (3.2%) and protected and conserved areas (30%) are spread across natural and managed lands, while all managed lands are managed for sustainability. The importance and scope of fully national spatial planning across 100% of territory that blends biodiversity considerations with the goals of other sectors is clear.

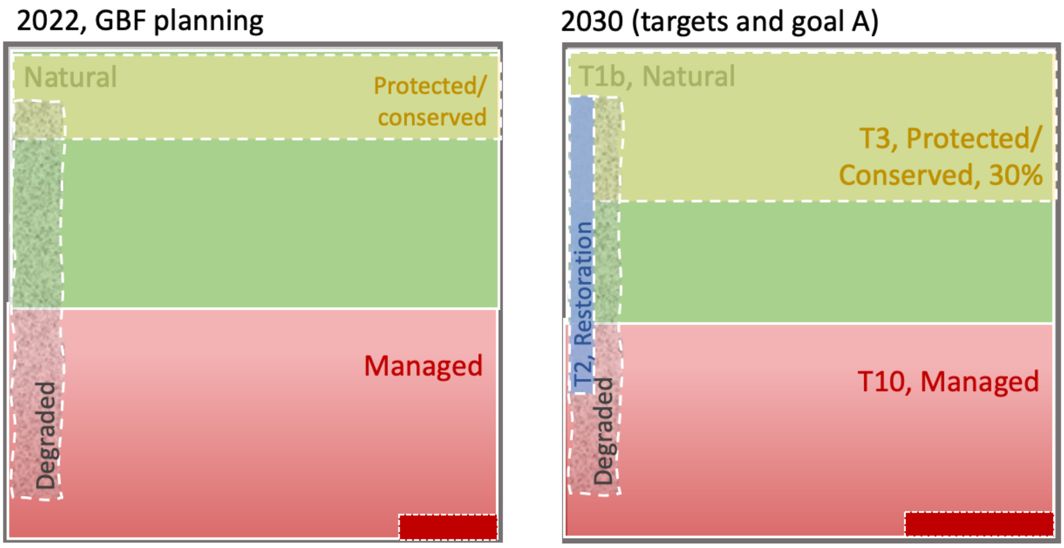

Figure 2. Illustration of area-based targets (1, 2, 3 & 10) in a national context. *Left, the proportions of terrestrial area that is considered 'natural' is approximately 50% globally (green) while a slightly smaller proportion is managed under agriculture and other production systems, and about 1% is urban. Approximately one third of managed lands may be considered 'degraded' (see Figure 1), with some spill-over into the most degraded parts of natural lands. Right, achievement in 2030 of Targets 1b (retention of intact/wilderness areas), 2 (restoration of 20% of degraded), 3 (protection of areas most important for biodiversity, to 30% of national area) and 10 (sustainable management of managed lands), and of goal A of an increase in intact ecosystem area of 5%.*

This illustration shows a number of features of importance to countries in implementing Targets 1, 2, 3 and 10, and the 2030 and 2050 ambitions for Goal A:

- target application starts with a country's reality today, and in this globally average case, land is split approximately equally between natural and managed landscapes. Communities and low-impact livelihoods and economies are strongly integrated within the former, while in the latter more intensive practices have significantly altered ecosystems to meet peoples' needs.
- Target 1 blankets the country to assure national assets are most efficiently used, now on a primary foundation of assuring environmental sustainability (addressed by the term 'biodiversity-inclusive' in the target wording).
- Target 10 meets this need by assuring all intensive production activities are changed to minimize impacts to nature.
- Targets 3 (conservation) and 1 (retaining intact/wilderness/critical ecosystems) seek to assure fully functioning components of nature, and those that are most important for biodiversity conservation and meeting critical human needs (such as carbon sequestration), are not degraded any further than the baseline in 2020.
- A significant proportion of natural but lightly impacted lands, not covered under the bullet points above (i.e., is neither under strong protection/conservation, nor transformed to production status, in this case almost 20% of all lands) is managed through spatially explicitly planning under Target 1 providing many options for development under the constraint of no further conversion to altered states, or degradation of nature.
- Degraded ecosystems, estimated at one third of managed ecosystems, likely overlap into the least intact natural areas. Restoration within these, under Target 2, can focus on local contexts and human needs as well as nature's needs.
- Achieving the increase in natural ecosystem area of 5% by 2030 requires some lands are taken out of production (T10) and put under restoration (T2) actions. Achieving the increase in ecosystem integrity targeted for 2030 is assisted by expanding protection and targeted restoration, particularly in the lands shifted from production to conservation. By simultaneously

implementing sustainable food and business commitments linked through the SDGs (e.g., by reducing consumption of meat, food waste at source and sink, etc.), the decrease in production area may be more than offset by biodiversity-friendly agricultural practices and transformations in food demand (see Science Brief on Target 10).

- This illustration has been based on land area, but the same principles apply for freshwater and marine ecosystems. The proportions may be different and primary condition variables may also be different based on fundamental differences in the environment (e.g., freshwater flows for rivers rather than area), but analogous principles can be applied.

As the 'globally average' case, Figure 2 illustrates how actions across all countries are aggregated to achieve the global goal. But implementation of targets must address different national contexts, so three country cases are presented (Figure 3). These illustrate countries with different starting points of natural vs. managed/transformed ecosystems. The figure illustrates the 2030 outcome, corresponding to the right panel in Figure 2.

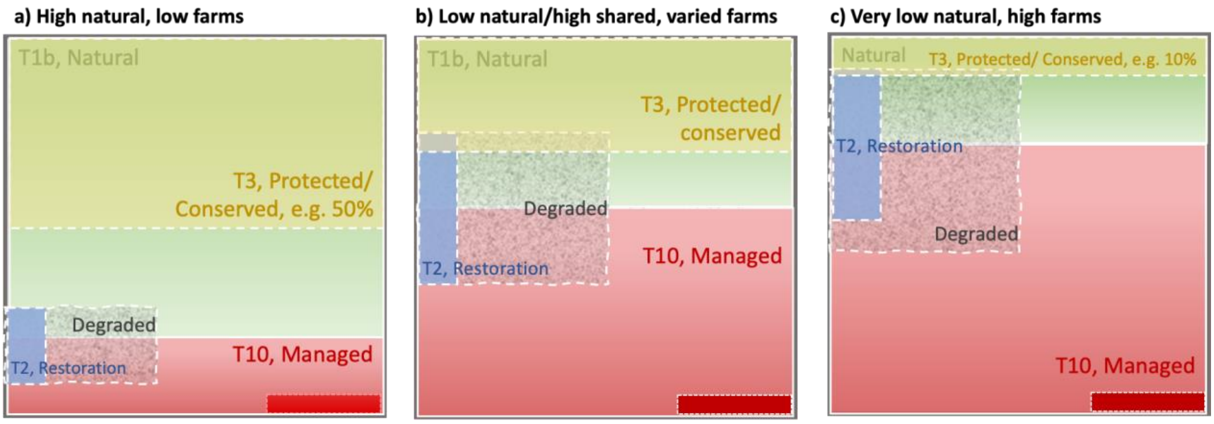

***Figure 3. Illustration of proportion of national area addressing Targets 1, 2, 3 and 10, among three country case studies** varying from high biodiversity/intactness at left to very low at right.*

These illustrations facilitate consideration of critical issues in achieving the four targets across countries, and ecosystem area and integrity outcomes of Goal A:

Case a:

- intact/natural area is high, so the country can contribute proportionately more towards the global protection/conservation target (T3).
- degraded area is low, so restoration may target improving sustainable production practices to ensure sustainability. There will be less need to address the specific target of increasing natural area as it is already high, and instead increasing integrity in existing (but somewhat degraded) natural areas could be prioritized.

Case b:

- with moderate natural areas grading into 'shared' areas (i.e., see condition 2 under the 3 conditions framework, Science Brief on Target 3) the country is capable of protecting 30% of area alongside targeted management and restoration actions to increase ecosystem area and integrity.
- restoration of ecosystem integrity in managed lands is a significant commitment that may increase the area of natural ecosystems, and does increase the integrity, and therefore the sustainability, of managed ecosystems.

Case c:

- transformed and production ecosystems are very high, so the contribution to global protection/ conservation may be low by area, but may be very significant for rare, vulnerable and their last remaining intact ecosystems.

- Restoration may address three options: a) restoring transformed (production) ecosystems back to natural, which would contribute to the increase in natural area required for goal A; or b) restoring degraded but still natural ecosystems to higher levels of health, and c) restoring production ecosystems to more sustainable and healthy production ecosystems. Neither b) nor c) would contribute to increasing ecosystem area, but they would contribute to increasing ecosystem integrity.

These cases illustrate the complex accounting that needs to be done of differing national contexts, and their differing contributions to meeting the global targets. Thus some countries may make high contributions to conservation and less to restoration, while other countries make lower contributions to conservation, but high to restoration, contributing to overall equity across the GBF. Realization of any of these cases is dependent on national circumstances, the requisite level of resource mobilization for implementation of the GBF and application of these global targets in the context of national priorities. Costs and benefits of the outcomes need to be weighed, acknowledging the findings in the accompany briefs on e.g., pollution (Target 7), climate (Target 8) and sustainable production systems (Target 10), that alongside supply and demand side efficiencies and waste reduction, and transformations to sustainable practices, that benefits often outweigh costs of assuring sustainability (Strassburg et al. 2020). The importance of fully national spatial planning (T1) is further emphasized by this, and of the multilateral cooperation framework among countries, to equitably address Targets 1b, 2, 3 and 10. Equity is also achieved through the resource mobilization framework, to assure adequate funding for actions to achieve the global targets.

3) Glossary

Notes to the reader: Underlined terms and definitions in plain font are from the GBF Glossary (CBD/WG2020/3/3/Add.2/Rev.1). *Text in italics* are additions to or comments made on GBF Glossary definitions.

Baseline condition or Reference state - A reference state for the ecological, economic or social condition describing the state of the system in question. The baseline condition may be associated with a historical state in the past, or a contemporary state observed in a relevant geographic location.

Baseline period - A historical period used to identify a specific baseline condition.

Baseline - Reference reporting period - The time period used as the starting point for reporting progress on targets and goals (most reasonably 2020, which was the end of the Strategic Plan for Biodiversity 2011-2020). “Baseline” is often used in place of “reference reporting period”. This has led to considerable confusion in negotiations. Consistently using “reference reporting period” would avoid further confusion.

***Critical ecosystems -** Ecosystems that are rare, unique, threatened, essential for planetary function, or which cannot be readily restored (Díaz et al. 2020, see Glossary Appendix-Box 1 for more detailed definition)*

Connectivity (Ecosystem) - “Connectivity (i.e., ecological connectivity) is the unimpeded movement of species and the flow of natural processes that sustain life on Earth. It may thus also refer to continuous ecosystems often connected through ecological corridors. There are two types of connectivity: structural (in which the continuity between ecosystems is identified) and functional (in which the movement of species or processes is verified).”[4]

***Converted ecosystems (see also transformed ecosystems):** Converted ecosystems are ecosystems that have been transformed from a natural state to non-natural state. This term is principally used for terrestrial ecosystems. On land converted ecosystems are primarily croplands and pastures that have the potential to be restored to natural ecosystems (Strassburg et al. 2020). Strassburg et al. (2020) identified 2,870 Mha of converted lands globally, including “54% were originally forests, 25% grasslands, 14% shrublands, 4% arid lands and 2% wetlands.” Note that this estimate of converted area is considerably less than the approximately 4900 Mha of land in crops and pastures identified by*

[4] UNEP/CMS/Resolution 12.26 (Rev.COP13)

the FAO (=38% of land area, IPBES 2019), perhaps because of substantial differences in defining natural vs. managed grasslands.

Degraded ecosystems - "Land degradation can occur either through a loss of biodiversity, ecosystem functions or services. From an ecological perspective, land degradation may include complete transformation in the class or use of the ecosystem, such as the conversion of natural grassland to a crop field, delivering a different spectrum of benefits, but also degradation of the "natural" or "transformed" system. Natural ecosystems are often degraded prior to being transformed. The transformed ecosystem that results from this conversion can, in turn, be degraded and see a reduction in the delivery of its new functions (e.g., an agricultural field where soil degradation and reduced soil fertility leads to reduced crops).

The same concepts are applicable to the degradation of marine and freshwater ecosystems. It may take the form of changed trophic structures in a marine community (through fishing pressure and selective removal of species), transformation of the soft and hard benthos (through repetitive sweeps of contacting gears, such as trawls) or artificial reef construction, to cite only a few examples. In the case of aquatic freshwater ecosystems, the construction of dams and reservoirs over river courses or the conversion of natural wetlands into rice paddies are examples of ecosystem transformation."[5]

Comments:

- *The definition of "degraded" ecosystems is highly value laden and also depends greatly on the metric that is used to measure degradation (IPBES 2019, UNCCD 2022). Because of this, the UNCCD (2022) estimated that degraded lands are roughly between 20 and 40% of total land surface. Substantially larger ranges have been reported previously (Gibbs & Salmon 2015). Estimates of degraded marine ecosystems also vary greatly: the percentage of stocks fished at biologically unsustainable levels was 34% in 2017 (FAO & INRAE 2020). A much stricter definition could be based on the observation that 87% of the ocean is sufficiently impacted by human influence that it should not be considered wilderness (Jones et al. 2018).*
- *Closer alignment with UNCCD definitions would provide more consistency across Multilateral Environmental Agreements (MEAs).*

Ecosystem / ecological integrity: "An ecosystem is generally understood to have integrity when its dominant ecological characteristics (e.g., elements of composition, structure, function, and ecological processes) occur within their natural ranges of variation and can withstand and recover from most perturbations" (CBD/SBSTTA/24/3/Add.2/Rev.1, para. 18). Moreover, Add.2 refers to "including species diversity and abundance and communities of interacting species within ecosystems" (para. 21). Indicators of ecosystem integrity may include the "structure, function and composition of an ecosystem relative to the pre-industrial range of variation of these characteristics" (Hansen et al. 2021. Towards monitoring ecosystem integrity within the Post-2020 Global Biodiversity Framework, https://doi.org/10.32942/osf.io/eyqw5)"

Comments:

- *See discussion of issues of definition of ecosystem and ecological integrity in Section 1.b.*

Intact ecosystems: *See "wilderness" since the definition in the GBF glossary is for "intact and wilderness areas" which are not necessarily the same thing. The term "intact" does not have a clear, commonly accepted definition in the scientific literature, but commonly refers to ecosystems that have a species composition and ecological functioning that is close to the natural state of the ecosystem under the prevailing soil and climate conditions as result of absence of disturbance, currently and in the mid to long-term past.*

***Like-for-like compensation** - To be successful in compensating for losses in natural ecosystem area, restoration should focus on replacing destroyed or badly degraded natural ecosystems with a similar ecosystem type, using a relatively fine level of definition of ecosystem type. These principals are often collectively referred to as like-for-like compensation (Díaz et al. 2020, Maron et al. 2021).*

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[5] CBD/POST2020/WS/2019/11/3, see also IPBES 2018, UNCCD 2022

***Managed ecosystems**: We suggest using the definition of Díaz et al. (2020). "Managed ecosystems are those whose biotic composition is the result of deliberate manipulation by people, this often being a stronger factor than climate or substrate. In many cases the main plant or animal assemblages are designed anew for the purposes of serving human ends, such as providing food, fibers, energy or recreation. Obvious examples are agricultural fields, orchards, urban parks, aquaculture ponds, artificial reefs, rice paddy terraces, and many plantations. "Managed" landscapes and seascapes should not be considered as "lost for nature"; they host the greatest proportion of the world's biodiversity of domesticated organisms… and also a significant proportion of wild biodiversity, including wild relatives of crops…" See also Glossary Appendix-Box 2*

Natural ecosystems: "Areas composed of viable assemblages of plant and/or animal species of largely native origin and/or where human activity had not essentially modified an area's primary ecological functions and species composition.[6]

Comments:

- *The term "natural ecosystem" does not have a clear, commonly accepted definition in the scientific literature.*
- *Highly natural and highly managed are two ends of a gradient. It is essential to address this issue in the glossary and indicate where the line between natural and managed is based on considerations below (see Glossary Appendix-Box 2 for details).*
- *In this brief we have used a pragmatic definition that focuses on high integrity, but allows for moderate human influence following the definition used in Díaz et al. (2020, Glossary Appendix-Box 2). This is not as strict as the criteria of very high integrity, intactness and large size used to define "wilderness". Estimates of global natural area based on criteria of similar those of Díaz et al. (2020), that is, ecosystems with low, but not necessarily very low human influence, are close to 50% of ice-free land area (range 48-56%, see synthesis of Riggio et al. 2020). Greater precision in quantifying natural area results from the lack of a widely accepted definition, and the difficulty in distinguishing between semi-natural and natural states, especially for grasslands (Riggio et al. 2020).*
- *IPBES (2019, natural ecosystem indicator based on FAO data) defines natural terrestrial ecosystems as all ecosystems that have not undergone transformation to croplands, grasslands or urban areas (about 38% of land). This definition means that a wide range of modified ecosystems are included, for example many moderate to heavily exploited forests, secondary forests, and extensive pasture are classified as natural using this definition. A case can be made for including some secondary forests and extensive pastures in the 'natural' category, but is a source of considerable debate and very large uncertainty in land cover classifications (Prestele et al. 2016).*
- *Some definitions of 'natural' are very strict such as: "An ecosystem where human impact has been of no greater influence than that of any other native species, and has not affected the ecosystem's structure since the industrial revolution. Human impact excludes changes of global proportions, such as climate change due to global warming." EEA (https://www.eea.europa.eu/help/glossary/eea-glossary/natural-ecosystem). Only about a quarter of the ice-free land surface is considered to have very low human influence (range 20-34%, see synthesis of Riggio et al. 2020).*
- *The choice of definition of "natural" greatly alters calculations of the extent and feasibility of net gains at global and national levels. Retaining a very strict definition of "natural" would mean excluding a very large fraction of restoration activities from consideration as contributing to increasing natural ecosystem area. It would also substantially lower estimates of the rates of natural ecosystem area loss and make it much easier to attain net gain objectives in Goal A (because the denominator for calculating net gain is much smaller, see Section 2b)[7] Such a definition could be harmful to biodiversity and NCP because areas outside such strictly defined areas play important roles in biodiversity conservation (Locke et al. 2019).*

[6] Definition used in UNEP-WCMC glossary www.biodiversitya-z.org
[7] UNCCD (2022)

Net gain - A goal either of no net loss or net gain of biodiversity is typically set (also referred to as net neutral and net positive goals, respectively) relative to a predetermined baseline and can entail concomitant absolute losses and gains across different places, the sum of which leads to zero or positive change at an aggregated spatial scale. The process is implemented through national planning processes and negotiations between government agencies, conservation actors, and developers, with elements of the process often formalized within an Environmental and Social Impact Assessment. The mitigation hierarchy comprises four broad steps that are intended to be implemented in order of priority sequentially: (1) avoiding, (2) minimizing, (3) remediating, and (4) offsetting.[8]

Comments:

- *This definition would gain in clarity by adding mathematical definitions of net gain in natural ecosystem area and natural ecosystem integrity (at least in an annex).*
- *It is unclear what the second sentence above has to do with the definition, it focuses on a particular case of implementation, and could be removed.*
- *Caveats concerning net loss / no net gain objective would provide a more complete definition of net gain (see Section 1.b)*

Restoration - IPBES has defined restoration as "any intentional activity that initiates or accelerates the recovery of an ecosystem from a degraded state" (2019). This definition covers all forms and intensities of the degradation state and, in this sense, is inclusive of the definition adopted by the Society for Ecological Restoration.[9] Ecosystem restoration means "assisting in the recovery of ecosystems that have been degraded or destroyed, as well as conserving the ecosystems that are still intact". Restoration can happen in many ways – for example, through actively planting or by removing pressures so that nature can recover on its own. It is not always possible – or desirable – to return an ecosystem to its original state.[10]

Comments:

- *As note in Sections 1b and 1c, it could be very helpful to have a coarse typology of restoration actions indicating how they contribute to ecosystem integrity and natural ecosystem area.*

Semi-natural ecosystems - *Semi-natural habitats have ecological assemblages that have been substantially modified in their composition, balance or function by human activities. They may have evolved through traditional agricultural, pastoral or other human activities and depend on their continuation to retain their characteristic composition, structure and function. Despite not being natural, these habitats and ecosystems often have high value in terms of biodiversity and the services they provide.*[11]

Shared lands - *sensu Locke et al. (2019).*

Transformed ecosystem *– Ecosystems that are transformed from a natural state to a non-natural state, typically for agriculture or forestry. See Glossary Appendix-Box 2*

Wilderness - The term "wilderness" is used to describe landscapes and seascapes that are biologically and ecologically largely intact, with a low human population density and that are mostly free of industrial infrastructure. The term "wilderness" is therefore not exclusive of people but, rather, of human uses resulting in significant biophysical disturbance that lead to significant changes in species composition or ecological functions. As a result, wilderness quality is often defined in terms of remoteness from urban settlements and modern infrastructure and the degree of ecological impacts from industrial activity. However, the term is not meant to suggest an area must be completely "pristine" or "untouched"

[8] See Arlidge et al, "A Global Mitigation Hierarchy for Nature Conservation", BioScience, vol. 68, Issue 5, May 2018, pp. 336-347, https://doi.org/10.1093/biosci/biy029; Business and Biodiversity Offsets Porgramme, (2012) Standard on Biodiversity Offsets et al. 2018, "The many meanings of no net loss in environmental policy", Nature Sustainability 1, 19–27 (2018) https://www.nature.com/articles/s41893-017-0007-7.
[9] https://www.cbd.int/doc/c/fcd6/bfba/38ebc826221543e322173507/post2020-ws-2019-11-03-en.pdf
[10] United Nations Decade on Ecosystem Restoration, https://www.decadeonrestoration.org/what-ecosystem-restoration
[11] Definition in UNEP-WCMC glossary www.biodiversitya-z.org

as there are few places remaining on Earth that meet this standard. Further, it must be recognized that the terms "intactness" and "integrity" are measured on a continuum and are not binary.[12]

Comments:

- *In addition to the criteria above, wilderness definitions typically include specific reference to very large size; i.e., large enough that all native biodiversity, including viable populations of wide-ranging species, can be maintained.*
- *Ambiguities in the definition of wilderness, challenges in data availability and interpretation, and differences in indicators used has resulted in a large range of estimates of what could be classified as wilderness.*
- *Locke et al. (2019) found that 18% of global land area could be considered wilderness. Using a criteria of "very low human influence" gives a range of 20-34% of land area for intact ecosystems, and could be used as an estimate of wilderness (see Riggio et al. 2020). At the extreme for terrestrial ecosystems, a recent study suggested that only "2.9% of the land surface can be considered to be faunally intact" (Plumptre et al. 2021, but see Grantham et al. (2020), suggesting that this is based on overly strict criteria) .*
- *In this and other briefs, we use the wilderness estimates of Locke et al. (2019) for terrestrial ecosystems. We do this because it is the most operational indicator for wilderness. Other estimates of wilderness area on land differ from this substantially (Riggio et al. 2020, see discussion in 'natural' definition).*
- *Jones et al. (2018) estimated that about 13% of the ocean can be considered wilderness because it is sufficiently free of human influence.*
- *There is large spatial overlap in areas considered wilderness and indigenous territories on land; as such, the role of IPLCs in the use and conservation of these areas should be taken into consideration (Fernández-Llamazares et al. 2020).*

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[12] Kormos et al. (2017). World Heritage, Wilderness and Large Landscapes and Seascapes. Gland, Switzerland: IUCN. viii + 70pp, https://portals.iucn.org/library/sites/library/files/documents/2017-028.pdf). See also Locke et al. 2019

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5) Background and Glossary Appendixes

Background Appendix-Box 1: Assumptions for net change in natural terrestrial ecosystem area calculations

Comments

These calculations for the two scenarios in Figure 1 are based on simple assumptions. They are principally intended to highlight how calculations of net changes in ecosystem area can be made, how they depend on actions taken in Targets 1 and 2, and general levels of ambition that are needed to achieve the net gain objectives in goal A of the first draft of the GBF.

Wording of targets

Wording of Targets 1 and 2 has been modified in the figure to reflect suggested wording in Section 1d. Similar assumptions about losses and restoration could have been made without this assumption, but this was done to illustrate how quantitative relationships between targets and Goal A are more straightforward with rewording.

Assumptions for all scenarios

- Global ice-free land area: About 13000 Mha (FAO ref)
- Percent land area natural: Approximately 50% of ice-free land is currently natural (Riggio et al. 2020, see discussion in Section 1 and Glossary).
- Current rates of loss of natural ecosystems: the current gross rate of deforestation is about 10 Mha per year (SCBD 2020, although other data sets suggest higher rates, for example the Global Forest Watch reports 11 Mha of tropical forest cover loss in 2021). The rate of loss of other ecosystems is not well known, in part because of the difficulty in distinguishing between the loss of pasture and natural grassland. As an educated best guess, it is assumed that total losses of natural ecosystem area are about double rates deforestation = 20 Mha per year. This rate of loss is used in all scenarios for the period 2021-2023. Global scenarios provide a very wide range of projected losses from 2020-2050: from about 10 Mha/yr to over 60 Mha / yr (see Section 2b).

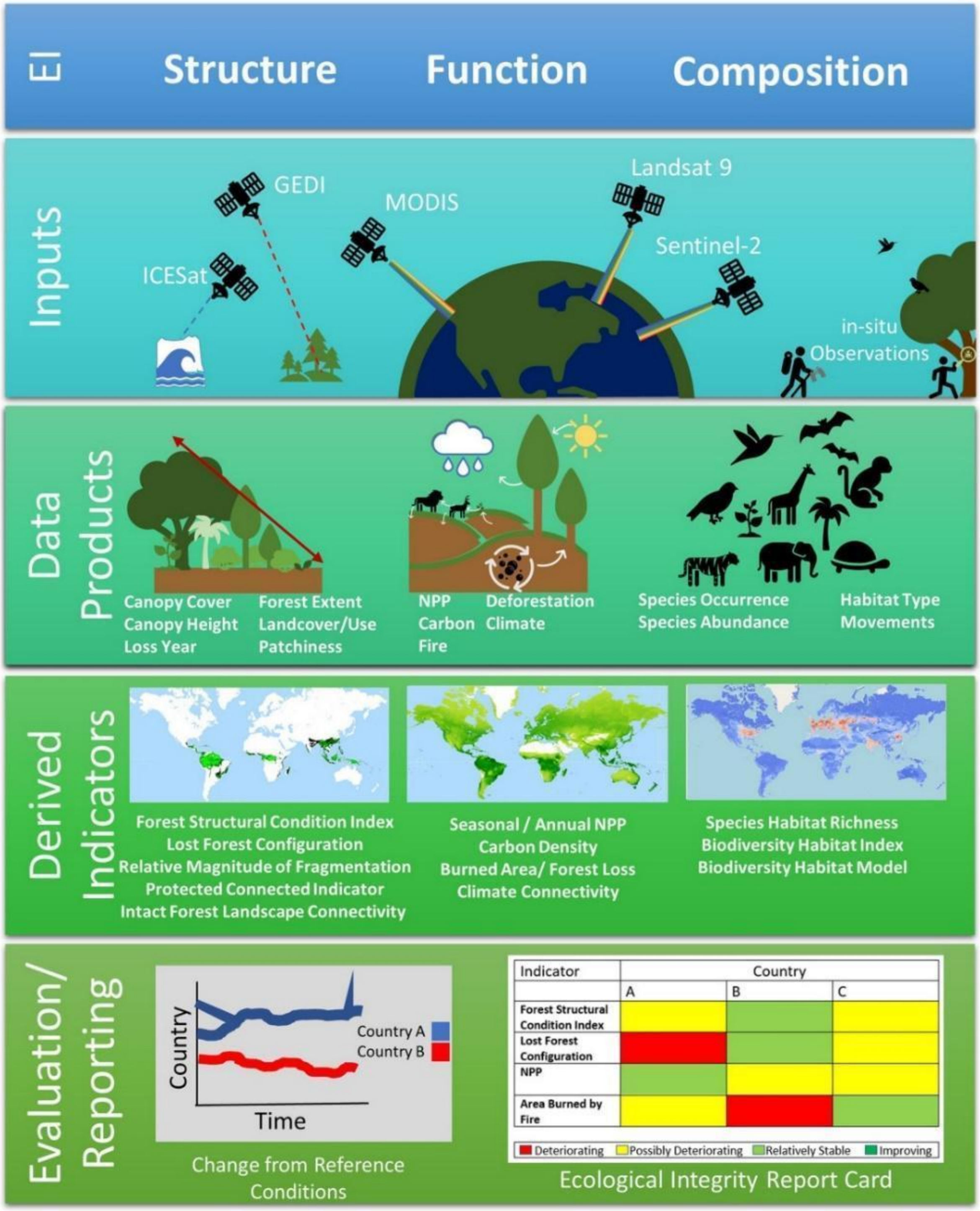
Assumptions for scenarios that meet Goal A net gain targets

- Reductions in losses: For the period 2023-2030 it is assumed that loss is halted in wilderness areas (as a proxy for critical ecosystems) and reduced by 70% (a quantitative translation of "significant reduction"). For the period 2031-2050 it is assumed that rates of loss are zero for all natural ecosystems. These are very ambitious objectives for 2030 and are exceptionally ambitious for 2050 (Strassburg et al. 2020).
- Rates of restoration of transformed to natural: For these scenarios, the rates of restoration were set based on what was needed to reach 5% net gain in natural ecosystem area in 2030 (=400 Mha) and 15% in 2050 (=1050 Mha). Note that Strassburg et al. (2020) estimated that 430 Mha of restoration of transformed to natural ecosystems " could avoid 60% of expected extinctions while sequestering 299 gigatonnes of CO2" and could be done without compromising food security.

Assumptions for scenarios that meet Goal A net gain targets

- Reductions in losses: Current rates of losses (20 Mha per year) are used for the time periods 2021-2030 and 2031-3050, as the simplest business-as-usual scenario.
- Rates of restoration of transformed to natural: The Bonn Challenge is for 350 Mha of forest restoration, but 66% of this commitment are forest plantations or agroforestry, putting an upper limit on the increase in natural area of forests of 115 Mha (SCBD 2020, UNCCD 2022). Restoration rates that would create new natural ecosystem area for non-forest ecosystems are poorly bounded. As a best educated guess, the rate of restoration of 150 Mha per decade was used for the period 2021-2030. This same rate of restoration was assumed for the period 2030.

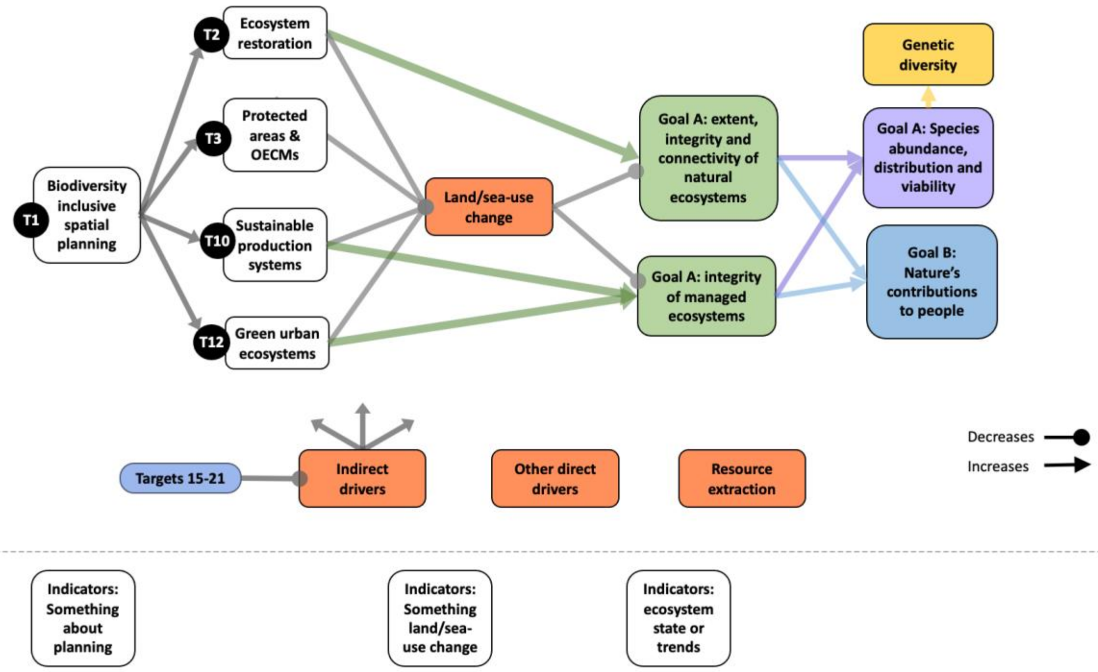
Background Appendix-Figure 1. Flow diagram of the recommended approach for tracking indicators of ecosystem integrity. From Hansen et al. (2021).



Background Appendix-Table 1. Description of indicators recommended for forest ecosystem integrity in the context of the post 2020 GBF. These individual metrics combine to form the Ecological Integrity Index. Steps are: 1) Identify “natural” cells within an ecoregion (e.g., Human Footprint < .4); 2) use the average value of the metric for these natural cells as representing maximum integrity; 3) derive a relative value for each cell across the ecoregion as a percentage of this average for natural cells); 4) average these relative values across all the metrics to derive the Ecological Integrity Index. Countries may choose to weight the individual relative metrics differentially based on national goals and targets. From Hansen et al. (2021).

Ecosystem Component / Indicator	**Description**	**Spatial / Temporal Resolution**	**Citation and Data Source**
Ecosystem Structure			
Forest Structural Condition Index (FSCI)	Vegetation structure within forest stands. Inputs include canopy cover, canopy height, and time since disturbance.	30 m 2012-2019 Tropical forests	Hansen et al. 2019
Lost Forest Configuration (LFC)	Index of the current patchiness of forest areas relative to the natural potential in forests without extensive human modification.	300m 2019. Plans for annual updates.	Grantham et al. 2020
Ecosystem Function			
MODIS Net Primary Productivity (NPP)	Functional measure of new biomass fixed by green plants through photosynthesis.	1 km 2000-2020	Running et al. 2004 Scurlock & Olson 2013
MODIS Burned Area	Fire history relates directly to the function of a given ecosystems disturbance regime. ….	250 m 2000-2020	Chuvieco et al. 2018
Ecosystem Composition			
Species Habitat Index by group	Average decrease in suitable habitat and populations of amphibian, bird and mammal species.	1km 2000-2018	Powers & Jetz 2019 Jetz et al. 2019
Local Biodiversity Intactness Index (BII)	Estimates how much of a terrestrial site's original biodiversity remains in the face of human land use and related pressure.	1 km 2001=2020	Newbold et al. 2016
Biodiversity Habitat Index (BHI)	Proportion of gamma diversity retained in any specified spatial reporting unit by combining best-available mapping of ecosystem integrity with beta-diversity modelling.	1 km 2005-2015 (2020 update in progress).	Hoskins et al. 2020 Mokany et al. 2020

Background Appendix-Figure 2. Contributions of spatial planning to ecosystem objectives of the GBF



Glossary Appendix. Additional comments on glossary definitions

Glossary Appendix - Box 1: Definition of critical ecosystems - Excerpt from CBD/SBSTTA/24/INF/9

"Ecosystems for which evidence of potential for restoration or replacement is lacking should be considered "no loss" ecosystems, because gains could not counterbalance losses of such ecosystems. NNL will almost certainly lead to inadequate outcomes for those ecosystems: for example, the inability to compensate for losses in some ecosystems, or the long time lags involved in such compensation, may lead to collapse of these ecosystems or have large impacts on planetary functions. These critical ecosystems may already be rare (small spatial area, e.g. specific island ecosystems), vulnerable (substantial habitat loss, intrinsically rare, or containing particularly important biotic assemblages, e.g. the Atlantic forest), or so important for planetary function, that any further decline in their area or integrity will lead to either a collapse/extinction of the ecosystem or of the function it provides, e.g. mangrove and seagrass ecosystems (Bland et al 2017 and 2018, Hughes et al 2018). For these critical ecosystems, an immediate "no loss" goal starting in 2020 should apply, complemented by increases in area and condition essential to mitigate their risk of collapse or loss of function. To support this, an inventory or catalogue of no loss critical ecosystems should be developed at national and global levels."

Glossary Appendix - Box 2: Natural to managed ecosystem gradient - Excerpt from Díaz et al. (2020) Supplement S3.

Goals for "natural" and "managed" ecosystems

On land and in water, ecosystems span a wide gradient of human influence, from those with relatively low human imprint (sometimes called wilderness) to those almost entirely assembled by humans, such as croplands, aquaculture ponds or green urban spaces. Goals need to be set across the whole gradient, attending to the specificities and values of these different landscapes. A pragmatic distinction between "natural" and "managed" ecosystems is needed to accommodate the different approaches these require in global goal-setting, policy and action, and also to avoid perverse outcomes from substitution among them (26) (see S4, annotations b-d).

"Natural" ecosystems, in the context of this article, are those whose species composition is predominantly native and determined by the climatic and geophysical environment. This is not to say they are devoid of human influence. The majority of "natural" ecosystems have been reconfigured by people to a significant extent, although not to a degree that would make them "human-made" in the same way that "managed" ecosystems are. Even those that would qualify as "wilderness" (7), such as the Amazonia, the great Western Woodlands of Australia, the Congo forests of central Africa, or the Canadian Arctic Archipelago, do not necessarily exclude human habitation, management and use, sometimes for millennia (27-29). Moreover, many of them are strongly managed to maintain their perceived natural state (30, 31). "Natural" ecosystems are not only reservoirs of biodiversity *per se*; even those at the most intact extreme have high practical value to people. For example, large areas of carbon-dense old-growth forest, quintessential examples of "human-less" nature, are crucial to global climate stability: halting their conversion and loss is essential to protecting nature and to achieving the Paris Climate Agreement (32).

"Managed" ecosystems, in the context of this article, are those whose biotic composition is the result of deliberate manipulation by people, this often being a stronger factor than climate or substrate. In many cases the main plant or animal assemblages are designed anew for the purposes of serving human ends, such as providing food, fibers, energy or recreation. Obvious examples are agricultural fields, orchards, urban parks, aquaculture ponds, artificial reefs, rice paddy terraces, and many plantations. "Managed" landscapes and seascapes should not be considered as "lost for nature"; they host the greatest proportion of the world's biodiversity of domesticated organisms (33) and also a significant proportion of wild biodiversity, including wild relatives of crops (33, 34).

While the "wildest" extreme of "natural" ecosystems and the most artificial extreme of "managed" ecosystems are starkly different, the limits between the highest-integrity "managed" ecosystems and the most heavily reconfigured "natural" ecosystems are necessarily arbitrary. Many traditional cultural landscapes lie in the transition zone. Examples include traditionally burned hunting and grazing lands in Africa and Australia (35), "dehesas" in southern Europe (36), hay and sheep grasslands in Europe and Asia (37, 38), and "vegas" (wet meadows) in the high Andes (39). This practical and somewhat artificial distinction therefore should not be conflated with unhelpful dichotomies such as "natural (=human-less) ecosystems for nature" versus "managed ecosystems for people"."

Glossary Appendix - Box 3: Land degradation (IPBES 2018)

Legend: "Land degradation can occur either through a loss of biodiversity, ecosystem functions or services, without a change in land cover class or use (1), or by the transformation to a derived ecosystem type such as the conversion of natural cover to a crop field (2), delivering a different spectrum of benefits, but also typically involving loss of biodiversity and reduction of some ecosystem functions and services. The transformed ecosystem can also be degraded with respect to the new social expectations associated with that land use (3). Degraded natural ecosystems can also be transformed to another ecosystem (4), or restored towards their original natural state, either completely or partially ("rehabilitated") (5). Degraded transformed ecosystems can be rehabilitated towards a less degraded state, with respect to the expectation for a deliberately modified landscape (6). Both degraded and undegraded transformed lands can, under many circumstances, be restored or rehabilitated towards their original natural state (7 and 8).