Commentary

Achieving global biodiversity goals by 2050 requires urgent and integrated actions

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Governments are negotiating actions intended to halt biodiversity loss and put it on a path to recovery by 2050. Here, we show that bending the curve for biodiversity is possible, but only if actions are implemented urgently and in an integrated manner. Connecting these actions to biodiversity outcomes and tracking progress remain a challenge.

Human impacts on Earth's biosphere are driving the global biodiversity crisis. Three-quarters of terrestrial ecosystems have been significantly altered, one-quarter of assessed plant and animal species are threatened with extinction, and genetic diversity is declining in wild and domesticated species.[1,2] This biodiversity crisis is also driving declines in nature's contributions to people (NCPs).[3] After failing to achieve the Aichi Biodiversity Targets of the Convention on Biological Diversity (CBD)—a set of 20 targets to address the drivers of biodiversity loss, safeguard biodiversity, and promote its sustainable use by 2020—governments are negotiating a new framework to put biodiversity on a path to recovery by 2050 (known as "bending the curve"[2,4]). The proposed actions in this new framework—referred to as the Post-2020 Global Biodiversity Framework (GBF)—can bend the curve for biodiversity, but only if implemented urgently and in an integrated manner.

Governments called for the development of the GBF in 2018 and for the creation of an Open-Ended Working Group (OEWG) within the CBD to support its preparation. The first draft of the GBF

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has 21 "targets" for actions to be initiated promptly and completed by 2030. These actions are collectively designed to achieve improvements in outcomes for ecosystems, species, and genetic diversity (goal A); meet people's needs through sustainable use of biodiversity (goal B); enable equitable sharing of the benefits of biodiversity (goal C); and mobilize resources (goal D) (see Note S1 for a summary of the GBF). These four goals include near-term objectives for 2030 (termed "milestones") and more ambitious long-term objectives for 2050. The GBF is to be finalized and adopted at the 15th meeting of the Conference of the Parties to the CBD (COP-15) later in 2022.

Since the initiation of the OEWG process, there has been considerable debate among governments, stakeholders, and scientists about the best way in which to structure and communicate the objectives of the GBF. Many of these debates have focused on whether to reduce the complexity of the GBF, in part to improve its understandability and utility. Some proposals have suggested focusing on a single "apex" goal for biodiversity, such as bringing species extinctions to near zero,[5] whereas others emphasize achieving no net loss of biodiversity[6] for the GBF. Most recently, at the OEWG meeting in Geneva (March 2022), there was considerable discussion on eliminating the milestones as separate items in the GBF to simplify its structure. Others have insisted on the need to reflect the complexity of biodiversity in the GBF with objectives addressing ecosystems, species, and genetic diversity as well as NCPs for both 2030 and 2050.[7,8] Proposed objectives such as "bending the curve for biodiversity" and "nature-positive" outcomes[4,8] (https://www.naturepositive.org/) reflect this complexity and have helped shift the discourse from focusing on slowing biodiversity loss to an objective of a net gain in biodiversity.

To better navigate the complexity of the GBF, governments and stakeholders are seeking clarification on how the action targets for 2030 are connected to the outcomes for 2030 and 2050, as well as how to meaningfully track progress (see CBD/WG2020/3/6). In this context, and reflecting on a recent document prepared for the CBD,[9] we provide an independent scientific synthesis of how actions across targets can achieve the outcomes for ecosystems, species, and genetic diversity defined in goal A of the GBF. The analysis in this paper refers to the first draft of the GBF (CBD/WG2020/3/3) and takes into account the outcomes of the recent negotiations in Geneva.

A systemic approach across all targets is essential

Our synthesis focuses on targets 1–10, which act on direct drivers of biodiversity loss, either simply (e.g., targets 6, 7, and 8 on invasive alien species, pollution, and climate change, respectively) or with high complexity (e.g., targets 1–3 and 10 on land- and sea-use change and targets 5 and 9 on direct exploitation). Linking the targets to drivers enables the proportional contribution of the direct drivers of biodiversity loss to serve as estimates of the relative contributions of actions under each target to the achievement of outcomes by 2030 and 2050 in goal A (Figure 1A, Note S2, and Tables S1–S3). Our analysis shows that no single target acting on direct drivers contributes more than 10%–15% to the achievement of any one biodiversity outcome of the GBF (Figure 1B). This analysis is most likely an underestimate given that the interactions among targets are not explicitly considered. There is no one-to-one linkage from any action target to a given biodiversity outcome. Instead, ''many-to-many'' relationships exist among them. Because many targets contribute to outcomes for biodiversity, there is a strong argument to retain the 2030 biodiversity outcomes (known as milestones in the first draft of the GBF) as part of the goals rather than integrate them into the targets, as debated in Geneva. Most importantly, this finding amplifies repeated calls from the scientific community to address the GBF in an integrated way[10] and for actors to treat the targets and goals of the GBF as an indivisible whole.

Case studies provide evidence that slowing and reversing biodiversity loss often, although not always, requires concerted actions on multiple direct and indirect drivers and that the relative contributions of actions are context dependent.[1] Multiple concerted actions were needed to avoid the extinction of bird and mammal species over the last two decades[11] and to restore population sizes of a wide range of bird, fish, and mammal species.[9] At the ecosystem level, concerted action on multiple drivers is needed to, for example, slow the degradation of coral reefs and Amazon forests.[9]

Transformative change to ''bend the curve''

The GBF explicitly acknowledges that transformative change is essential for attaining ambitious biodiversity objectives. This involves deep, systemic changes in society, such as rapid shifts to more sustainable production and consumption (especially in food systems), greatly increased financial and human resources for conservation and restoration, deep cuts in subsidies that are harmful to biodiversity,[12] and broader involvement of stakeholders, including Indigenous peoples and local communities (IPLCs).[1,2] However, transformative change remains a nebulous concept for many actors. Scenarios for biodiversity can help clarify this concept by quantitatively examining various aspects of transformative change and characterizing how they contribute to achieving the 2030 and 2050 biodiversity outcomes.

We have distilled three types of scenarios for 2030 and 2050 that are directly pertinent to the GBF according to a synthesis of several recent studies on global sustainability scenarios (Figure 2, Note S3, and Table S4). Achieving ambitious targets for expanding protected areas (PAs), species management plans, and ecosystem restoration, as well as halting the conversion of existing natural ecosystems, is projected to slow future biodiversity loss (Figure 2, ''conservation and restoration'' scenario type). Reducing biodiversity loss further is hampered in part by insufficient progress on restoring biodiversity, ecosystem function, and connectivity in working lands that occupy approximately 40% of the global land surface. There are also concerns that these targets might be only partially achieved given that current trends show that PAs are under-resourced, progress in establishing ecologically representative PAs has been slow, and restoration efforts using good ecological practices have been increasing but not at the rate and scale needed.[2,13] Without substantially greater efforts on these actions, focusing on large increases in the extent of PAs is likely to have a limited effect on slowing and reversing the biodiversity loss observed in the last decade (Figure 2, ''continued trends + 30% PA'' scenario type). Thus, the aim to protect 30% of the planet by 2030, supported by the intergovernmental High Ambition Coalition for Nature and People, is largely insufficient by itself to halt biodiversity loss. The degradation of biodiversity can be halted by 2030 and recovery toward 2050 can be initiated only when indirect drivers of biodiversity loss are addressed (Figure 2, ''transformative change'' scenario type; see Table S4 for projections to 2050). These scenarios of transformative change all rely heavily on rapid transitions to sustainable production and consumption, and meeting a broad range of the Sustainable Development Goals can make even greater progress (Note S3). Limiting climate change to 1.5°C is essential for achieving ambitious biodiversity goals in all scenarios.

Act now and sustain actions due to time lags

There are significant time lags between the impacts of drivers and the realization of their full impacts on biodiversity. For example, we know that past and ongoing habitat loss and fragmentation contribute to the future erosion of population genetic diversity and species' extinctions (referred to as ''extinction debt''). Current deterioration in the functioning of terrestrial and marine ecosystems is also driven in large part by the legacies of human impacts that occurred decades or centuries ago.[14] Because these lags frequently span decades, it is important to implement action now to mitigate the impacts of drivers and shorten the duration and lower the cumulative loss of biodiversity and ecosystem processes in the coming decades.

Recovery from large-scale disturbances—such as fishery collapses due to overfishing or deforestation—also involves time lags. Recovery lags can range from years to several decades and, in some cases, much longer. Biodiversity is also lost during recovery. Compared with reference ecosystems, these recovery ''debts'' measured as annual deficits during recovery can be 46%–51% for abundance and 27%–33% for species diversity.[14] Active restoration of degraded ecosystems can result in faster or more complete ecosystem recovery and thus curtail recovery debts and shorten time lags.

It is important to set objectives for biodiversity outcomes for 2030 that account for these lags, as well as the lags in setting motion the actions to reduce drivers of biodiversity loss. Resources strategically invested now will enable the achievement of biodiversity outcomes framed by the GBF in the medium (5–10 years) and longer (10–30 years) terms (Figure 1A).

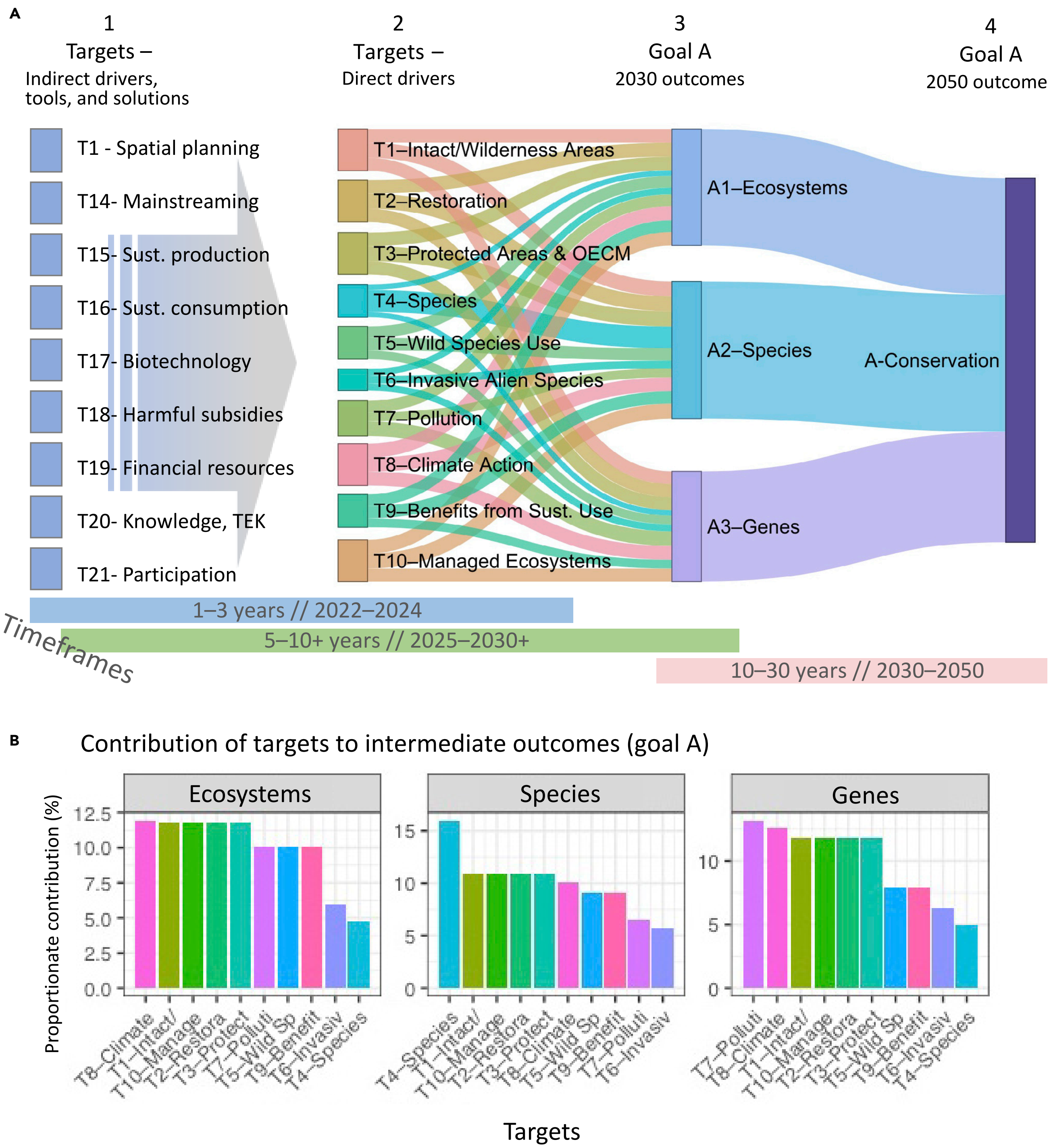

Figure 1. Proportionate contribution of targets 1–10 to the achievement of goal A in the first draft of the GBF, including outcomes for the three major components of biodiversity in 2030 and 2050

(A) The width of lines linking targets 1–10 to 2030 outcomes was estimated from the contributions of direct drivers to biodiversity loss[1] (see Note S2 for details). Targets 11–13 and goals B and C were not included in this analysis because the study focused on goal A, and comparable quantification of the contributions of targets to 2030 objectives for goals B and C are not available. Targets 1 and 14–21 (related to indirect drivers, tools, and solutions) are shown as supporting the implementation of targets 1–10. These broad relationships, as indicated by the large-headed arrow, are analyzed in the "transformative change" section, but it is not possible to quantify the specific relationships and proportionate contributions of individual targets.[1] Two aspects of target 1 are split in this illustration: "spatial planning" (indirect driver: institutions) and "retaining intact and wilderness areas" (direct driver: land- and sea-use change). Time frames needed for investing in and delivering positive results for each target and resulting outcomes are shown, emphasizing the role of 2030 objectives in monitoring progress toward 2050 objectives (see main text on time lags).

(B) The proportionate contribution of targets 1–10 to 2030 outcomes for ecosystems, species, and genes is highlighted (as in targets 1 and 7). The sum of proportions in each subfigure is 100%.

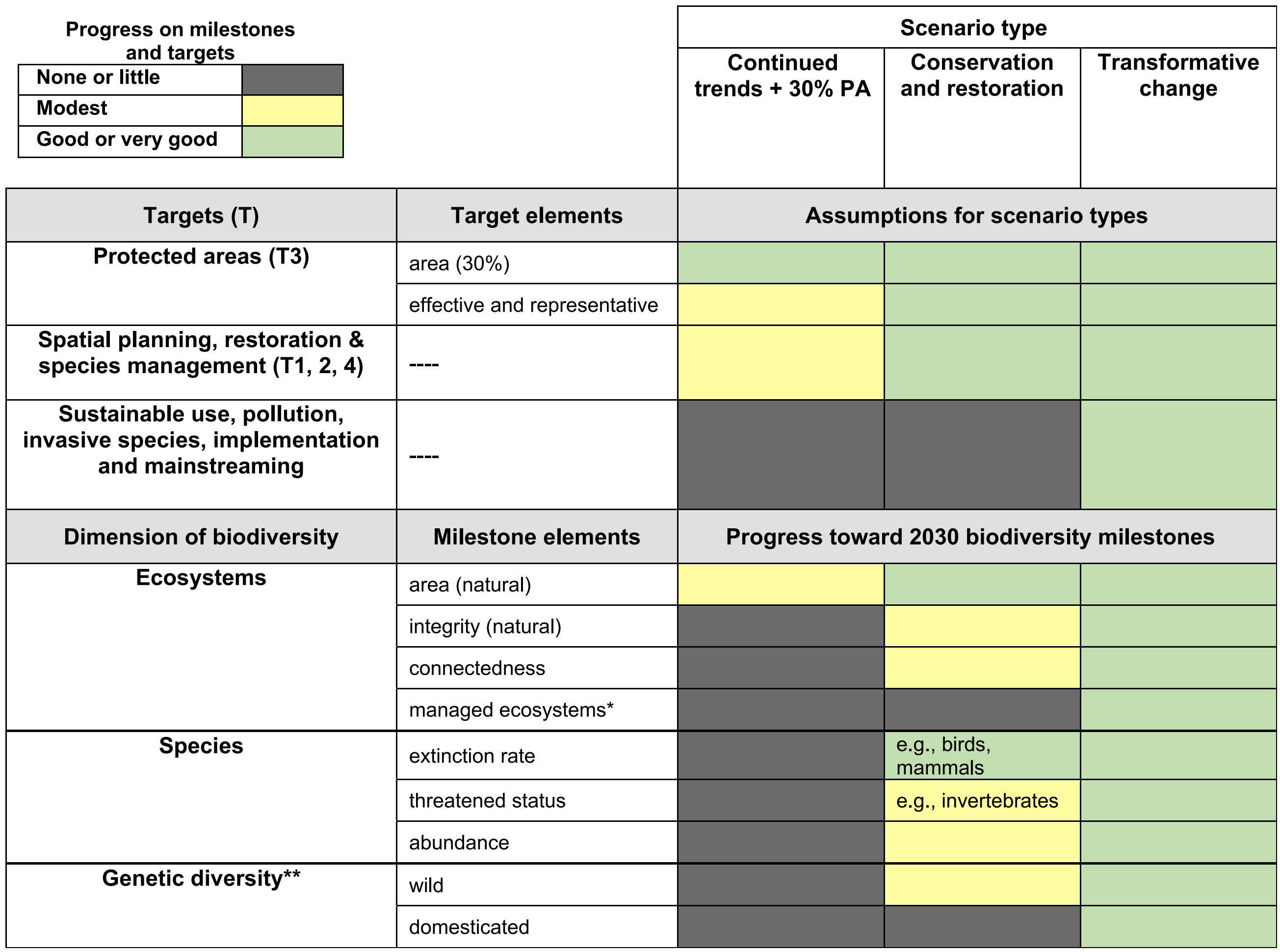

Figure 2. Three types of scenarios with different levels of achievement of targets of the GBF and projected progress toward achieving the 2030 milestones for biodiversity

The "continued trends + 30% PA" scenario type is based on observed progress on direct and indirect drivers of biodiversity loss over the recent past; one exception is a large increase in the extent of protected area (PA) coverage, but there is weak to moderate progress on other elements of this target. The "conservation and restoration" scenario type is based on ambitious actions focusing on traditional conservation actions and restoration but assuming continued trends for other major direct and indirect drivers. The "transformative change" scenario type assumes high ambition and achievement of all of the supporting processes and means of implementation in the GBF, as well as achievement of conservation and restoration targets.

*Managed ecosystem integrity is included here because it is a component of the 2050 goal for biodiversity even though it is not part of the 2030 milestones.

**Progress toward genetic diversity milestones has high uncertainty because these milestones are rarely addressed in scenarios, and much less information on trends is available, especially in wild species. See Note S3 for more details and projections to 2050.

International collaboration and a multiscale approach

Biodiversity loss arises from multiple drivers acting across multiple spatial scales. The forces arising from a globalized economy mean that biodiversity loss due to direct drivers in one location can be caused by indirect drivers elsewhere, such as land-use change caused by demand for agricultural goods operating far away. International collaboration should be strengthened and focused on how to share efforts adequately and equitably to mitigate the drivers of biodiversity loss; protect, conserve, and restore biodiversity; and account for differences in national capacities and access to means of implementation. Apportioning responsibilities varies by case; almost a third of the global mitigation efforts needed to alleviate the extinction risk of terrestrial mammals, birds, and amphibians have been found to lie within just five countries.[15] In other cases, wide-ranging benefits of collaborative efforts across countries at regional scales have been shown.[9] When we extrapolate to the global scale, it is clear that local realities and priorities, as well as the capacity to implement actions, are varied and require effective, transformative approaches to share the effort to achieve global ambitions.[16] Greater dialogue is needed between national agendas and global priorities and needs, supported by responsibility and transparency mechanisms under development for the GBF, including regular review of enhanced collaboration for implementation.[17]

A monitoring framework and review mechanisms

Current biodiversity indicators in the GBF monitoring framework can detect trends for several dimensions of biodiversity (e.g., ecosystem extent, species extinction risk). Some indicators in the GBF also capture trends in a subset of drivers of biodiversity loss, but it is essential that a complete set of indicators for drivers and the chain of causal links to biodiversity responses and NCPs be made available and applied at the right scales. Specifically, the monitoring framework of the GBF could be greatly strengthened in three ways: (1) a detection and attribution system is needed to establish where and to what extent drivers are causing biodiversity change and to assess the degree to which actions addressing these drivers are leading to expected biodiversity outcomes; (2) a mechanism for integrating, aggregating, and disaggregating biodiversity information is needed to assess progress at national and global scales; and (3) a set of readily monitored predictive indicators,[18] built from explanatory models of the effects of drivers on biodiversity, are needed to guide proactive planning and action. These new capacities would allow the monitoring framework to both track progress and support adaptive policy and action.

The current capacity for biodiversity monitoring is unequally distributed across the globe, resulting in biases in our understanding of biodiversity change across taxa, ecosystems, and biomes.[9] An assessment of the resources needed for building an adequate global biodiversity observation system is urgently needed. Investment in monitoring would sustain, enhance, and mainstream current global biodiversity information infrastructures, develop local and national capacities to collect new data, make data openly accessible, and implement workflows that can rapidly deliver the information needed for tracking trends in indicators (target 19; Note S1). This investment would allow stakeholders to produce and use appropriate biodiversity indicators, thereby improving the equity in monitoring capacities and supporting action on drivers across all regions. This capacity is essential to ensuring responsibility and transparency during the implementation of the GBF.[17]

Conclusions

Top-level science-policy documents increasingly call for transformative change to address the global biodiversity crisis.[1,2] Our findings confirm this by showing that reversing biodiversity loss by 2050 requires integrated and ambitious action across all targets of the GBF. Our analysis further indicates that actions in the first draft of the GBF could plausibly bend the curve for biodiversity by 2050 only if these actions are implemented promptly and comprehensively and with active monitoring and reporting. We emphasize the importance of actions on both direct and indirect drivers, assuring and strengthening participation and leadership by IPLCs, and treating the targets and goals of the GBF as an indivisible whole.

SUPPLEMENTAL INFORMATION

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DECLARATION OF INTERESTS

The authors declare no competing interests.

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One Earth, Volume *5*

Supplemental information

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Note S1. Description of GBF goals, milestones, targets, and background on process

At COP 14 in Egypt, countries adopted a preparatory process for the development of the post-2020 Global Biodiversity Framework, and established an Open-Ended Working Group (OEWG), co-chaired by Francis Ogwal, Ghana and Basile van Havre, Canada. The preparatory process is participatory, aiming for comprehensive consultation with a broad range of stakeholders across regions and themes. The first OEWG meeting was held in Nairobi, 27-30 August 2019, at which the scope of the framework was discussed, and the co-chairs were requested to prepare the zero order draft (ZOD) of the framework. A schedule for consultations was also set out at this meeting.

The second OEWG meeting took place in Rome, 24 - 29 February 2020. Participants reviewed the ZOD and commented on the proposed goals and targets. SBSTTA was requested to provide a technical and scientific review, and the co-chairs were tasked to prepare a first draft. This first draft is available as CBD/WG2020/3/3[1]. Due to the COVID pandemic, part I of the 3rd meeting of the OEWG was conducted virtually from 23 August to 3 September 2021, providing an opportunity for parties and stakeholders to exchange views, and to prepare for part II of OEWG-3, to take place in Geneva, March 2022.

Elements of the post-2020 Global Biodiversity Framework

2050 Vision

The vision of the framework is a world living in harmony with nature where: “By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people.”

2030 Mission

The mission of the framework for the period up to 2030, towards the 2050 vision is: “To take urgent action across society to conserve and sustainably use biodiversity and ensure the fair and equitable sharing of benefits from the use of genetic resources, to put biodiversity on a path to recovery by 2030 for the benefit of planet and people.”

2050 Goals and 2030 Milestones

The framework has four long-term goals for 2050 related to the 2050 Vision for Biodiversity. Each 2050 goal has a number of corresponding milestones to assess, in 2030, progress towards the 2050 goals. The four goals and their associated milestones are:

Goal A. 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, supporting healthy and resilient populations of all species, the rate of extinctions has been reduced at least tenfold, and the risk of species extinctions across all taxonomic and functional groups, is halved, and genetic diversity of wild and domesticated species is safeguarded, with at least 90 percent of genetic diversity within all species maintained.

Milestone A.1 - Net gain in the area, connectivity and integrity of natural systems of at least 5 percent.

Milestone A.2 - The increase in the extinction rate is halted or reversed, and the extinction risk is reduced by at least 10 per cent, with a decrease in the proportion of species that are threatened, and the abundance and distribution of populations of species is enhanced or at least maintained.

Milestone A.3 - Genetic diversity of wild and domesticated species is safeguarded, with an increase in the proportion of species that have at least 90 per cent of their genetic diversity maintained.

Goal B. Nature's contributions to people are valued, maintained or enhanced through conservation and sustainable use supporting the global development agenda for the benefit of all.

Milestone B.1 - Nature and its contributions to people are fully accounted and inform all relevant public and private decisions.

Milestone B.2 - The long-term sustainability of all categories of nature's contributions to people is ensured, with those currently in decline restored, contributing to each of the relevant Sustainable Development Goals.

Goal C. The benefits from the utilization of genetic resources are shared fairly and equitably, with a substantial increase in both monetary and non-monetary benefits shared, including for the conservation and sustainable use of biodiversity.

Milestone C.1 - The share of monetary benefits received by providers, including holders of traditional knowledge, has increased.

Milestone C.2 - Non-monetary benefits, such as the participation of providers, including holders of traditional knowledge, in research and development, has increased.

Goal D. The gap between available financial and other means of implementation, and those necessary to achieve the 2050 Vision, is closed.

Milestone D.1 - Adequate financial resources to implement the framework are available and deployed, progressively closing the financing gap up to at least US $700 billion per year by 2030.

Milestone D.2 - Adequate other means, including capacity-building and development, technical and scientific cooperation and technology transfer to implement the framework to 2030 are available and deployed.

Milestone D.3 - Adequate financial and other resources for the period 2030 to 2040 are planned or committed by 2030.

2030 Action Targets

The framework has 21 action-oriented targets for urgent action over the decade to 2030. The actions set out in each target need to be initiated immediately and completed by 2030. Together, the results will enable achievement of the 2030 milestones and of the outcome-oriented goals for 2050. Actions to reach these targets should be implemented consistently and in harmony with the Convention on Biological Diversity and its Protocols and other relevant international obligations, taking into account national socioeconomic conditions.

1. Reducing threats to biodiversity

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 percent of degraded freshwater, marine and terrestrial ecosystems are under restoration, ensuring connectivity among them and focusing on priority ecosystems.

Target 3. Ensure that at least 30 percent 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.

Target 4. Ensure active management actions to enable the recovery and conservation of species and the genetic diversity of wild and domesticated species, including through ex-situ conservation, and effectively manage human-wildlife interactions to avoid or reduce human-wildlife conflict.

Target 5. Ensure that the harvesting, trade and use of wild species is sustainable, legal, and safe for human health.

Target 6. Manage pathways for the introduction of invasive alien species, preventing, or reducing their rate of introduction and establishment by at least 50 per cent, and control or eradicate invasive alien species to eliminate or reduce their impacts, focusing on priority species and priority sites.

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.

Target 8. Minimize the impact of climate change on biodiversity, contribute to mitigation and adaptation through ecosystem-based approaches, contributing at least 10 GtCO2e per year to global mitigation efforts, and ensure that all mitigation and adaptation efforts avoid negative impacts on biodiversity.

2. Meeting people’s needs through sustainable use and benefit-sharing

Target 9. Ensure benefits, including nutrition, food security, medicines, and livelihoods for people especially for the most vulnerable through sustainable management of wild terrestrial, freshwater and marine species and protecting customary sustainable use by indigenous peoples and local communities.

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.

Target 11. Maintain and enhance nature’s contributions to regulation of air quality, quality and quantity of water, and protection from hazards and extreme events for all people.

Target 12. Increase the area of, access to, and benefits from green and blue spaces, for human health and well-being in urban areas and other densely populated areas.

Target 13. Implement measures at global level and in all countries to facilitate access to genetic resources and to ensure the fair and equitable sharing of benefits arising from the use of genetic resources, and as relevant, of associated traditional knowledge, including through mutually agreed terms and prior and informed consent.

3. Tools and solutions for implementation and mainstreaming

Target 14. Fully integrate biodiversity values into policies, regulations, planning, development processes, poverty reduction strategies, accounts, and assessments of environmental impacts at all levels of government and across all sectors of the economy, ensuring that all activities and financial flows are aligned with biodiversity values.

Target 15. All businesses (public and private, large, medium and small) assess and report on their dependencies and impacts on biodiversity, from local to global, and progressively reduce negative impacts, by at least half and increase positive impacts, reducing biodiversity-related risks to businesses and moving towards the full sustainability of extraction and production practices, sourcing and supply chains, and use and disposal.

Target 16. Ensure that people are encouraged and enabled to make responsible choices and have access to relevant information and alternatives, taking into account cultural preferences, to reduce by at least half the waste and, where relevant the overconsumption, of food and other materials.

Target 17. Establish, strengthen capacity for, and implement measures in all countries to prevent, manage or control potential adverse impacts of biotechnology on biodiversity and human health, reducing the risk of these impacts.

Target 18. Redirect, repurpose, reform or eliminate incentives harmful for biodiversity, in a just and equitable way, reducing them by at least US$ 500 billion per year, including all of the most harmful subsidies, and ensure that incentives, including public and private economic and regulatory incentives, are either positive or neutral for biodiversity.

Target 19. Increase financial resources from all sources to at least US$ 200 billion per year, including new, additional and effective financial resources, increasing by at least US$ 10 billion per year international financial flows to developing countries, leveraging private finance, and increasing domestic resource mobilization, taking into account national biodiversity finance planning, and strengthen capacity-building and technology transfer and scientific cooperation, to meet the needs for implementation, commensurate with the ambition of the goals and targets of the framework.

Target 20. Ensure that relevant knowledge, including the traditional knowledge, innovations and practices of indigenous peoples and local communities with their free, prior, and informed consent, guides decision-making for the effective management of biodiversity, enabling monitoring, and by promoting awareness, education and research.

Target 21. Ensure equitable and effective participation in decision-making related to biodiversity by indigenous peoples and local communities, and respect their rights over lands, territories and resources, as well as by women and girls, and youth.

Note S2. Quantification of target-milestone interactions under Goal A

This section justifies the quantification of target - milestone interactions used in Fig. 1, also contained in CBD/SBSTTA/24/INF/31[2]. The 21 action targets in the GBF correspond roughly to direct and indirect drivers and to nature's contributions to people as classified by IPBES (3), as well as tools and solutions for delivering the GBF. However this is a coarse mapping based on interpretation of the text of the targets and milestones, and the biological relationships that underpin them, contributing to the many-to-many relationships among the targets and to the outcomes. For example, Target 1 explicitly cites addressing land and sea use change and retaining intact ecosystems thus implying an ecosystem focus, but spatial planning also provides the framework for implementation and integration of all action targets together. Also, the IPBES assessment (3) assigned a greater impact of land and sea use change on species dimensions of biodiversity than on ecosystem dimensions (Tables S1 and S2), such that while Targets 1, 2 and 3 may relate most directly to land and sea use change as a driver, it impacts more on species (Milestone A.2) than ecosystem (Milestone A.1) outcomes.

The contribution of each target to the milestones of the GBF was derived using two sources of information: a) the attribution of direct drivers of biodiversity decline to components of biodiversity (fig. 2.2.22.A[3]), and b) for those targets not covered by this (Targets 9 and 10), expert judgement. The approach used by IPBES (3, Section 2.2.6), was based on reviews of the scientific literature and on attribution by Indigenous Peoples and Local Communities (IPLCs) to assign weightings of drivers to components of biodiversity at a global level, among four world regions and major realms. This approach has limitations, and weightings may be quite different especially at smaller scales and specific systems.

The relative contribution of each direct driver to the decline in elements of biodiversity was estimated from Fig. 2.2.22.A in IPBES (3), the total attributed to 'other' causes of decline was assigned evenly across the direct drivers (assuming equal interactions across them; Table S1). These results were aggregated to the three components of biodiversity in milestones A1, A2 and A3 (Table S1). Table S3 documents application of the contributions of each driver to Targets 1-8, and assumptions made for Targets 9 and 10.

Table S1. *Relative contribution of each direct driver to decline in dimensions of biodiversity, on a scale of zero to 10 (Source: IPBES (3), Section 2.2.6, fig 2.2.22.A). CC - climate change; Exp - direct exploitation of organisms; IAS - invasive alien species; LSUC - land and sea use change; Pol - Pollution.*

Component	Dimension	CC	Exp	IAS	LSUC	Pol	Other	Total
Genetic (A3)	**Genetic composition**	1.9	1.4	1.1	2.1	2.4	1.1	10
Species (A2)	**Species populations**	1.2	2.4	1.3	3.1	1.2	0.7	10
	Species traits	2.1	2.4	1.3	1.7	1.5	1.1	10
	Community composition	2.0	1.4	1.1	2.9	1.6	1.0	10
Ecosystem (A1)	**Ecosystem function**	1.9	1.7	1.3	2.4	1.6	1.1	10
	Ecosystem structure	1.5	2.1	0.8	2.1	2.3	1.1	10

Table S2. *Aggregate contributions for the three components of biodiversity in milestones A1 (ecosystems), A2 (species) and A3 (genetic), from Table S1. As in Table S1, all values were rescaled so that the sum of values per row = 10.*

Component	CC	Exp	IAS	LSUC	Pol
Ecosystem (A1)	1.93	2.14	1.26	2.51	2.16
Species (A2)	1.96	2.27	1.42	2.73	1.62
Genetic (A3)	2.09	1.60	1.29	2.37	2.66
Overall weight	***5.98***	***6.01***	***3.96***	***7.62***	***6.43***

Table S3. *Weighting of Targets 1-10 in addressing Milestones A1, A2 and A3 in the global biodiversity framework. Values in the cells obtained from Table S1.*

Target	Milestone			Comments
	A1	A2	A3	
T1 - Spatial planning, intact and wilderness areas	2.5	2.7	2.4	Spatial planning focuses on ecosystems/habitats, but is relevant to species as well. Overall magnitude assumed equal to LSUC (Targets 2 & 3)

T2 - Restoration	2.5	2.7	2.4	Restoration actions cross a full range across ecosystem, species and genetic actions, so equivalent to Targets 1 and 3.
T3 – Protected and conserved areas	2.5	2.7	2.4	From IPBES (3) direct driver quantification. Protection is equivalent to ecosystem actions and LSUC.
T4 - Species recovery	1.0	4.0	1.0	Target 4 focuses on direct species actions, not attributable to direct drivers, so heaviest weight is applied to species actions, with a minor component on genetic diversity and habitat actions.
T5 - Wild species use	2.1	2.3	1.6	From IPBES (3) direct driver quantification on direct exploitation of species.
T6 - Invasive alien species	1.3	1.4	1.3	From IPBES (3) direct driver quantification on invasive alien species.
T7 - Pollution	2.2	1.6	2.7	From IPBES (3) direct driver quantification on pollution.
T8 - Climate change	2.5	2.5	2.5	Increased from IPBES (3) direct driver quantification of climate change impacts, to be equivalent to largest driver, LSUC (Targets 1, 2, 3) and equal impact across dimensions.
T9 - Share benefits	2.1	2.3	1.6	Equivalent to Target 5, addresses benefit sharing from wild species use.
T10 - Use/extraction	2.5	2.7	2.4	Managed ecosystems - assume equivalent to Land/Sea Use Change (Targets 1, 2, 3).

Note S3. Synthesis of global sustainability scenarios

This supplement consists of verbatim extracts from CBD/SBSTTA/24/INF/31[2] (14 January 2022).

"Scenarios on land for the period 2030-2050 show:

- Continued trends in direct and indirect drivers result in rapid degradation of all dimensions of biodiversity (although genetic diversity is rarely addressed).
- Strong conservation actions, including protected areas, can play a very important role in reducing biodiversity loss. However, protected areas with weak levels of protection, weak management or placement in areas of low biodiversity value are of little, or no, help in slowing biodiversity loss.
- Expansion of protected areas to 50% of land ("half Earth") may substantially increase the risk of food insecurity.
- Limiting global warming to 1.5°C or below is essential to meeting ambitious biodiversity goals, especially for 2050 and beyond.
- Conservation and restoration can slow biodiversity loss, but only transformative changes of underlying drivers such as unsustainable production and consumption can halt and reverse biodiversity loss over the long term.
- Limiting global warming to 1.5°C or below is essential to meeting ambitious biodiversity goals, especially for 2050 and beyond.
- Conservation and restoration can slow biodiversity loss, but only transformative changes of underlying drivers such as unsustainable production and consumption can halt and reverse biodiversity loss over the long term."

"Table S4 provides a qualitative synthesis of six very recent scenario studies that are relevant to setting ambition for the GBF goals, milestones and targets for terrestrial biodiversity (see also Appendix 1.3 of (2) for a quantitative analysis of the land use impacts on species extinction risk). We compare four scenarios that have a basis in the relatively complex Shared Socio-economic Pathways developed in support of the IPCC. Three of these, (4-6), have made significant modifications to increase the representation of sustainability and explicitly add biodiversity conservation. Two of the scenarios (7, 8) use statistical extrapolations of land use trends along with relatively simple assumptions about the land use implications of protected areas and food systems. These scenarios highlight the importance of i) well-implemented conservation and restoration and ii) transformations of agricultural production, sustainable diets and reducing food waste. Only two of the studies include climate change impacts on biodiversity (3, 5) and both indicate that even low levels of climate change greatly increase the risks for biodiversity."

"In addition to these global sustainability scenarios, other scenarios, models and observations indicate that expansion of protected areas in the future could help slow biodiversity loss, but not halt it, and are only beneficial when properly placed and well-managed. Observations show that species abundance within protected areas has continued to decline, the placement and resourcing of the majority of protected areas has been poor, and more than half of recent protected areas have had significant increases in threats to biodiversity (9, 10). Scenarios and models suggest that substantial increases in protected areas on land could be beneficial for biodiversity (Table S4), but most of these scenarios assume that protected areas in the future are well-managed, well-placed and properly resourced. Scenarios with non-optimal placement, or weak management indicate that increasing protected area coverage will be of little value and even counter-productive (9, 11, 12). Scenarios and models also suggest that expansion to 50% global coverage of land area could compete for land with agriculture and substantially increase the risk for food security, especially in sub-Saharan Africa (Table S4)."

"At regional scales, (4) and (7) also point to the regional diversity of what constitutes the most efficient combinations of actions on direct and indirect drivers, and spillovers across regions via trade. Direct actions to stop habitat loss in one region are ineffective if the harmful activities relocate to another region as many of these activities are tightly linked to international value chains (13). Direct actions to stop habitat loss are, thus, best complemented with action to replace these commodities by lower footprint alternatives to decrease the overall pressures, and thus decrease the risk of spillovers across regions. Sustainability scenarios and models for terrestrial systems at local scales show a combination of careful spatial planning, the introduction of sustainable or regenerative production practices and a decrease of overall pressure through the value chain."

"An important caveat concerning these scenarios is that they do not consider invasive alien species, pollution from fertilizers, pesticides and light (see Appendix 1.6 for discussion of future light impacts on species), bushmeat hunting, and many other factors that will increase human impacts on biodiversity. In addition, only two studies take into account climate change impacts on biodiversity."

Table S4. *Analysis of six global sustainability scenarios. The four studies at the top of the table are based on modifications of the Shared Socio-economic Pathways (SSP) scenarios and Representative Concentration Pathway (RCP) greenhouse gas concentration trajectories developed in support of the Intergovernmental Panel on Climate Change (IPCC). Background color: continued trends = grey, conservation and restoration only = blue, transformative change = green. Arrows indicate the qualitative response of biodiversity for habitat area, biodiversity intactness and extinction risk (downward arrows indicate more species threatened with extinction). Short arrows indicate responses for "current" to 2030 (first arrow) and then 2030 to 2050 (second arrow). Long arrows indicate responses for "current" to 2050. Color and angle of arrow indicate direction of response compared to reference date which is 2010 or 2015 for the long arrows and first short arrow, 2030 for second short arrow: black = very negative ; grey = negative; orange = negative but slower than current trend; yellow = stabilization; green = slight improvement; blue = substantial improvement. In the "Scenario assumptions" column: SE = socio-economic scenario; CC = climate change scenario and projected 2050 global warming. Other abbreviations: BD = biodiversity, EAT = Lancet EAT diet, ES = ecosystem services, KBA = key biodiversity areas, NDC = Nationally Determined Contributions to climate mitigation for Paris Agreement, NA = not applicable, Wild. = wilderness.*

Study	Scenario name	Scenario assumptions	Protected Areas	Restoration	Food Systems	Climate impact	Habitat Area	Intactness	Extinction Risk	Comments
(3, 14) Biodiversity model = Multi-model	Continued trends	SE = SSP3 CC = RCP6.0 ≈ 3-4°C by 2100	None explicit	None explicit	Continued trends	no				
	Continued trends	SE = SSP3 CC = RCP6.0 ≈ 3-4°C by 2100	None explicit	None explicit	Continued trends	yes				
	Sustainability	SE = SSP1 CC = RCP 2.6 ≈ 2°C, stable	30%, reduced deforestation	Not explicit	Close yield gaps Sustainable consumption	no				Weaker land use constraints than other sustainability scenarios
	Sustainability	SE = SSP1 CC = RCP 2.6 ≈ 2°C, stable	30%, reduced deforestation	Not explicit	Close yield gaps Sustainable consumption	yes				idem
(4)	Continued trends	SE = SSP2 CC = NA	no further expansion beyond 2010	None explicit	Continued trends	no				
Biodiversity model = Multi-model	Conservation and restoration	SE = SSP2 CC = NA	40% by 2020 (KBAs & Wild. areas)	≈5 million km^2 by 2050 (≈ 4%)	Continued trends	no				Also includes land-use planning over all land
	+ Sustainable production & consumption	SE = SSP1 CC = NA	40% by 2020 (KBAs & Wild. areas)	≈10 million km^2 by 2050 (≈ 8%)	Close yield gaps; Healthy diet, -50% meat; -50% food waste	no				Also includes land-use planning over all land
(5)	Continued trends	SE = SSP2 CC ≈ 2,1°C rising	17% by 2020, no further expansion	None explicit	Continued trends	yes				
Biodiversity model = GLOBIO	Conservation = "Sharing the Planet Earth"	SE = SSP2 CC = 2,1°C rising	30% by 2050, focus ES	Rehabilitation	Continued trends	yes				
	Conservation ="Half Earth"	SE= SSP2 CC = 2,1°C rising	50% by 2050, focus BD	Ecological restoration	Continued trends	yes				Food security risk above SSP-2 baseline; highest food security risk
	Conservation = "Sharing the Planet" + Sustainability	SE = SSP2 CC = 1.6°C stable	30% by 2050, focus ES	Rehabilitation	Close yield gaps; Sustain diet, -50% animal products; -50% food waste	yes				Lowest food security risk Largest improvement regulating services

Study	Scenario name	Scenario assumptions	Protected Areas	Restoration	Food Systems	Climate impact	Habitat Area	Intactness	Extinction Risk	Comments
(6)	Continued trends	SE = SSP2 CC = NDC ≈ ??°C	None explicit	None explicit	Continued trends	no	↘↘	↘↘	—	Nat. habitat = primary and secondary vegetation?
Biodiversity model = BII	Sustainability + Climate mitigation	SE = SSP1 CC ≈ <1.5°C	Increase in forest protection	?	Close yield gaps Global equity	no	→→	→→	—	
	+ SDG package	+ try to meet all SDG objectives CC ≈ <1.5°C	Above + expansion to biodiversity hotspots	?	Close yield gaps Sustain. diets (EAT) Reduce food waste Global equity	no	↗↗	↗↗	—	Actions have strong synergies across multiple SDG goals. Lower food security risk
(8)	30% Strict Protected Area	SE = PA optimization CC - none	34% by 2030	19 million km^2	Continued trends	no	→	—	↘	Arrows use 2015 baseline
Biodiversity model = habitat suitability	100% Spatial planning	SE = land use optimization CC - none	17% + Spatial planning	14.5 million km^2	Continued trends	no	→	—	→	Lowest trade-off between biodiversity and food security
	30% Strict PA + spatial planning everywhere else	SE = both of above CC - none	34% by 2030	18 million km^2	Continued trends	no	→	—	→	Highest food security risk
(7)	Continued trends	SE = Statistical extrapolation of land use trends	Continued trends	Continued trends	Continued trends	No	↘	—	↘	
Biodiversity model = habitat suitability	Spatial planning	SE = Global land use planning	Protect high priority areas	Not explicit	Continued trends	No	↘	—	↘	
	+ Sustainable production and consumption	SE = above + Sustainable agriculture and consumption	idem	Regrowth on abandonned land	Close yield gaps Sustain. diets Reduce food waste	No	↗	—	→	

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