Achieving global biodiversity goals by 2050 requires urgent and integrated actions

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Introduction

Human impacts on the Earth's biosphere are driving the global biodiversity crisis. Three-quarters of terrestrial ecosystems have been significantly altered, a 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 (NCP; 1,2). Following the failure to achieve the Aichi Biodiversity Targets of the Convention on Biological Diversity (CBD)—a set of twenty targets to address the drivers of biodiversity loss, safeguard biodiversity and promote its sustainable use by 2020—governments are negotiating a new framework intended to put biodiversity on a path to recovery by 2050 (also known as "bending the curve"; 2,3). We provide evidence that the proposed actions in this framework can bend the curve for biodiversity, but only if these actions are implemented urgently and in an integrated manner.

The first draft of this new framework—referred to as the Post-2020 Global Biodiversity Framework (GBF)—has twenty-one "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); meeting peoples' needs through sustainable use of biodiversity (Goal B); equitable sharing of benefits of biodiversity (Goal C); and mobilization of resources (Goal D, see SM 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. 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 GBF is to be finalized and adopted at the COP-15 of the CBD later in 2022. The analysis in this paper uses the first draft of the GBF (CBD/WG2020/3/3) as a reference, but also takes into account the outcomes of negotiations in Geneva.

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 understandability and utility to a non-scientific audience). Some proposals have suggested focusing on a single "apex" goal for biodiversity that would, for instance, prioritize bringing extinctions to near zero (4), restoring ecosystem integrity (5), or achieving no net loss of natural ecosystems (6). Most recently, at the Geneva meeting of the OEWG, there was considerable discussion on eliminating the "milestones" as separate items to help simplify the 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 NCP for both 2030 and 2050 (7). Proposed objectives such as "bending the curve for biodiversity" and "nature positive" outcomes (2,3, www.naturepositive.org) reflect this complexity, and have also 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 targets for action for 2030 are connected to the outcomes for 2030 and 2050, as well as how to meaningfully track progress (see CBD/WG2020/3/6 for a summary of the state of negotiations). In this context, we provide an independent scientific synthesis of how actions across the targets can achieve the outcomes for ecosystems, species, and genetic diversity defined in Goal A of the GBF. Further details of this synthesis can be found in an information document that was prepared for the CBD (8).

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 greater complexity, e.g. targets 5 and 9 on direct exploitation, and targets 1, 2, 3 and 10 on land and sea use change (this last group of ecosystem-based targets also addresses direct drivers). Linking targets to drivers enables the proportional contribution of the direct drivers of biodiversity loss (1) to serve as estimates of the relative contributions of actions under each target and of the targets to the achievement of outcomes by 2030 and 2050 in Goal A (Fig. 1A, S2). Our analysis shows that no single target acting on direct drivers makes more than a 10-15% contribution to the achievement of any biodiversity outcome of the GBF (Fig. 1B). This analysis likely underestimates the interlinkages between actions and outcomes for biodiversity because it doesn't include interactions among targets. 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, this strongly argues in favor of retaining objectives for biodiversity outcomes for 2030 as part of the goals, rather than integrating them into the targets as was debated at the Geneva OEWG meeting. Most importantly, this finding reinforces and amplifies repeated calls from the scientific community to address the GBF in an integrated way (7), and for actors to treat the targets and goals of the GBF as an indivisible whole.

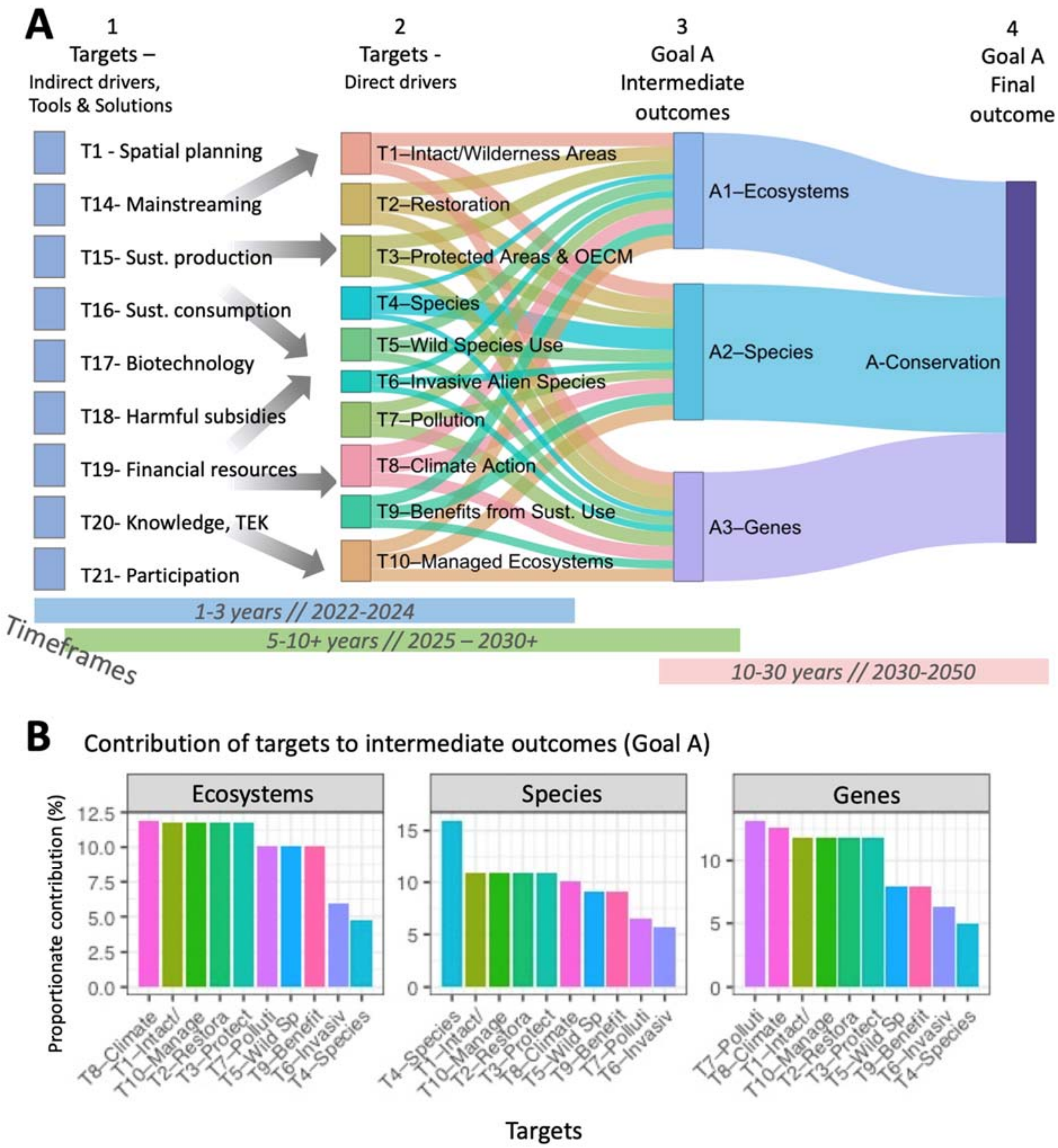

Figure 1. *Proportionate contribution of Targets 1-10 to achievement of Goal A in the first draft of the Global Biodiversity Framework, including outcomes for the three major components of biodiversity in 2030 and 2050. (A) the width of lines linking Targets 1-10 to 2030 outcomes were estimated from direct driver contributions to biodiversity loss (IPBES 2019), see S2 for details. Targets 11-13 and goals B and C were not included in this analysis as 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 multiheaded arrow, are analysed in the "Transformative change" section, but the specific relationships and proportionate contributions of individual targets are not possible to quantify (IPBES 2019). Two aspects of Target 1 are split in this illustration, separating 'spatial planning' (indirect driver:*

institutions) and 'retaining intact and wilderness areas' (direct driver: land/sea use change). Timeframes needed to invest in and deliver positive results for each target and resulting outcomes are shown, emphasizing the role of objectives for 2030 being used to monitor progress towards objectives for 2050 (and see main text on time lags). (B) the proportionate contribution of Targets 1-10 to 2030 outcomes for ecosystems, species and genes are highlighted (as in 1,7). The sum of proportions in each subfigure adds to 100%.

Case studies provide additional 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 required to avoid the extinction of bird and mammal species over the last two decades (9) and to restore population sizes of a wide range of bird, fish, and mammal species (8). At the ecosystem level, concerted action on multiple drivers is needed to, for example, slow the degradation of coral reefs and Amazon forests (8).

Transformative change is needed to "bend the curve" towards net biodiversity gain

The GBF explicitly acknowledges that transformative change is essential for attaining ambitious biodiversity objectives and that 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 (Sumaila et al., 2021) and broader involvement of stakeholders including Indigenous Peoples and Local Communities (IPLCs; 1,2). The notion of transformative change remains persistently vague for many actors. Scenarios provide a means of helping to clarify this concept by quantitatively examining various aspects of transformative change, and characterizing how they could contribute to achieving the biodiversity outcomes for 2030 and 2050 of the GBF.

Table 1. *Three types of scenarios with different levels of achievement of targets of the GBF (top part of table) and projected progress towards achieving the 2030 milestones for biodiversity (bottom part of table; see S3 for more details and projections to 2050). The "Continued Trends +30% Protected Areas" scenario type is based on observed progress on direct and indirect drivers of biodiversity loss over the recent past, with one exception which is a large increase in the extent of protected area coverage but with 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. Note: *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 they are rarely addressed in scenarios and much less information on trends is available, especially in wild species.*

Progress on Milestones and Targets

None or Little	
Modest	
Good or very good	

		Scenario Type		
		Continued Trends +30% PA	**Conservation & Restoration**	**Transformative Change**
Targets (T)	**Target elements**	**Assumptions for scenario types**		
Protected areas (T3)	*Area (30%)*			
	Effective & Representative			
Spatial planning, restoration & species management (T1, 2, 4)	----			
Sustainable use, pollution, invasive species, implementation and mainstreaming	----			
Dimension of biodiversity	**Milestone elements**	**Progress towards 2030 biodiversity Milestones**		
Ecosystems	*Area (natural)*			
	Integrity (natural)			
	Connectedness			
	*Managed ecosystems**			
Species	*Extinction rate*		e.g., Birds, Mammals e.g., Invertebrates	
	Theatened status			
	Abundance			
Genetic diversity**	*Wild*			
	Domesticated			

We have distilled three types of scenarios for 2030 and 2050 that are directly pertinent to the GBF based on a synthesis of several recent global sustainability scenarios studies (Table 1, S3, 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 (Table 1, "Conservation and Restoration"). 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 concerns that these targets may only be partially achieved since 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 (2,10). Without substantially greater efforts on these actions, focusing on large increases in the extent of PAs is likely to have a limited effect on halting and reversing the biodiversity loss observed over the last decade (Table 1, "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[1], is a critically important element of the GBF, but largely insufficient (and possibly impractical) by itself to halt biodiversity loss. The degradation of biodiversity can be halted by 2030, and recovery towards 2050 can be initiated only when indirect drivers of biodiversity loss are addressed (Table 1, "Transformative Change", see SM Table S4 for projections to 2050). These scenarios of transformative change all rely heavily on rapid transitions to sustainable production and consumption, especially in food systems, and even greater progress can be made by meeting a broad range of Sustainable Development Goals (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 magnitude of biodiversity change. For example, we know past and ongoing habitat loss and fragmentation will contribute to the future erosion of population genetic diversity and species' extinctions (commonly 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 (8). Because these lags frequently span decades, it is important to mitigate the impacts of

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[1] www.hacfornatureandpeople.org also known as 30X30 and currently includes 82 participating countries and the European Commission.

drivers now to shorten the duration and lower the cumulative loss of biodiversity and ecosystem processes in the coming decades.

Recovery from large-scale disturbances — such as collapses of fisheries due to overfishing, logging, or the restoration of ecosystems after 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, and these recovery 'debts' can amount to 46–51% for abundance and 27–33% for species diversity (11). Active restoration 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 in motion the actions to reduce drivers of biodiversity loss. As such, objectives for biodiversity outcomes by 2030 play a critical role as milestones in measuring intermediate progress towards more ambitious outcomes for 2050. 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 (Fig. 1A).

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 may be caused by indirect drivers, such as the 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 will vary by case; almost a third of the global mitigation efforts required to alleviate the extinction risk of terrestrial mammals, birds and amphibians have been found to lie within just five countries (12). In other cases, wide-ranging benefits of collaborative efforts across countries at regional scales have been shown (8). When extrapolating to the global scale, it is clear that local realities and priorities, as well as the capacity to implement actions would vary, and require effective, transformative approaches to share the effort to achieve global ambitions (13). Greater dialogue between national agendas and global priorities and needs will be necessary, supported by responsibility and transparency mechanisms under development for the GBF, including a more regular review of enhanced collaboration for implementation (14).

A monitoring framework and review mechanisms to achieve outcomes

Current biodiversity indicators in the GBF monitoring framework allow the detection of trends for several dimensions of biodiversity (e.g., ecosystem extent, species extinction risk). Some indicators in the GBF also capture trends in 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 is made available and applied at the right scales. Specifically, the monitoring framework of the GBF could be greatly strengthened in three ways: (i) 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 on these drivers are leading to expected biodiversity outcomes, (ii) a mechanism for biodiversity information integration, aggregation and disaggregation is needed to assess progress at national and global scales, and (iii) a set of predictive indicators (15) 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 track progress and support adaptive policy and action.

Current biodiversity monitoring capacity is unequally distributed across the globe, resulting in biases in our understanding of biodiversity change across taxa, ecosystems, and biomes (8). An assessment of the resources needed to build an adequate global biodiversity observation system is urgently needed. Investment in monitoring would address Target 19 (S1) and would sustain and enhance 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 to track trends in indicators. 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 ensure responsibility and transparency during the implementation of the GBF (14).

Conclusions

Top-level science-policy documents increasingly call for transformative change to address the global biodiversity crisis (1,2). Our findings confirm this need 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, if these actions are implemented promptly. We emphasize the importance of actions on both direct and indirect drivers, assuring participation and leadership by indigenous peoples and local communities, and treating the targets and goals of the GBF as an indivisible whole, rather than focusing on its individual elements.

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