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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.

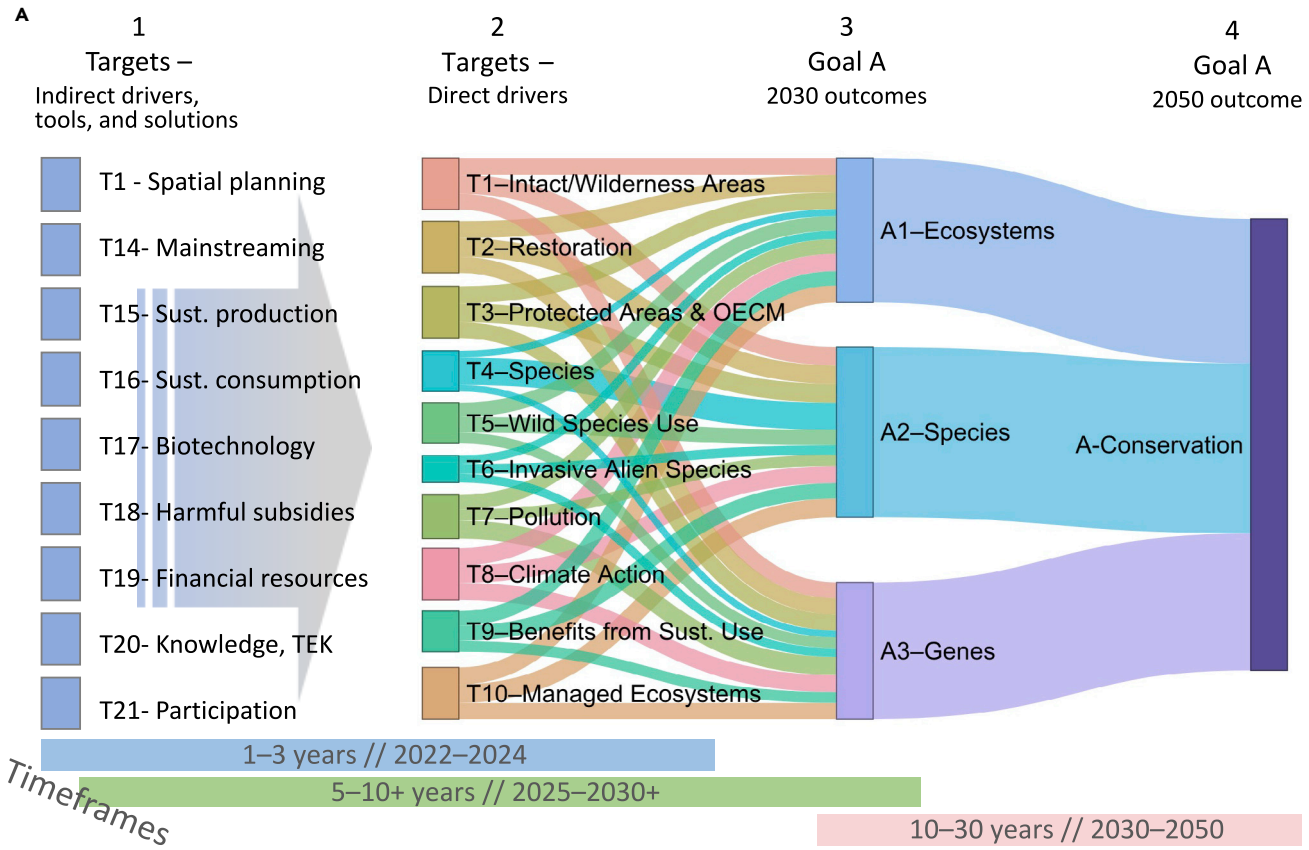
We have distilled three types of scenarios for 2030 and 2050 that are directly pertinent to the GBF according to a synthesis of several recent studies on global sustainability scenarios (Figure 2, Note S3, and Table S4). Achieving ambitious targets for expanding protected areas (PAs), species management 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 in 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).



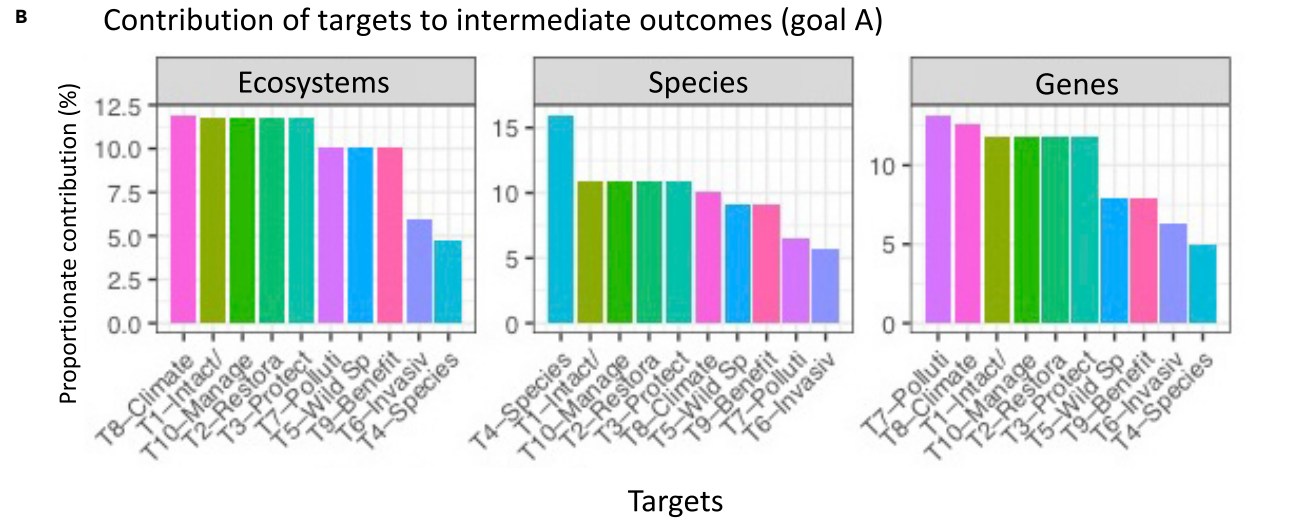


Figure 1. Proportionate contribution of targets 1–10 to the achievement of goal A in the first draft of the GBF, including outcomes for the three major components of biodiversity in 2030 and 2050

(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%.

Progress on milestones and targets	
None or little	
Modest	
Good or very good	

		Scenario type		
		Continued trends + 30% PA	Conservation and restoration	Transformative change
Targets (T)	**Target elements**	**Assumptions for scenario types**		
Protected areas (T3)	area (30%)			
	effective and representative			
Spatial planning, restoration & species management (T1, 2, 4)	---			
Sustainable use, pollution, invasive species, implementation and mainstreaming	---			
Dimension of biodiversity	**Milestone elements**	**Progress toward 2030 biodiversity milestones**		
Ecosystems	area (natural)			
	integrity (natural)			
	connectedness			
	managed ecosystems*			
Species	extinction rate		e.g., birds, mammals	
	threatened status		e.g., invertebrates	
	abundance			
Genetic diversity**	wild			
	domesticated			

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

Supplemental information can be found online at https://doi.org/10.1016/j.oneear.2022.05.009.

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DECLARATION OF INTERESTS

The authors declare no competing interests.

REFERENCES

1. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://doi.org/10.5281/zenodo.3831673.
2. Secretariat of the Convention on Biological Diversity (2020). Global Biodiversity Outlook 5. https://www.cbd.int/gbo.
3. Loreau, M., Hector, A., and Isbell, F. (2022). The Ecological and Societal Consequences of Biodiversity Loss (John Wiley & Sons). https://www.wiley.com/en-us/The+Ecological+and+Societal+Consequences+of+Biodiversity+Loss-p-9781119902911.
4. Mace, G.M., Barrett, M., Burgess, N.D., Cornell, S.E., Freeman, R., Grooten, M., and Purvis, A. (2018). Aiming higher to bend the curve of biodiversity loss. Nat. Sustain. *1*, 448–451.
5. Rounsevell, M.D.A., Harfoot, M., Harrison, P.A., Newbold, T., Gregory, R.D., and Mace, G.M. (2020). A biodiversity target based on species extinctions. Science *368*, 1193–1195.
6. Maron, M., Simmonds, J.S., Watson, J.E.M., Sonter, L.J., Bennun, L., Griffiths, V.F., Quétier, F., von Hase, A., Edwards, S., Rainey, H., et al. (2020). Global no net loss of natural ecosystems. Nat. Ecol. Evol. *4*, 46–49.
7. Nicholson, E., Watermeyer, K.E., Rowland, J.A., Sato, C.F., Stevenson, S.L., Andrade, A., Brooks, T.M., Burgess, N.D., Cheng, S.-T., Grantham, H.S., et al. (2021). Scientific foundations for an ecosystem goal, milestones and indicators for the post-2020 global biodiversity framework. Nat. Ecol. Evol. *5*, 1338–1349.
8. Bull, J.W., Milner-Gulland, E.J., Addison, P.F.E., Arlidge, W.N.S., Baker, J., Brooks, T.M., Burgass, M.J., Hinsley, A., Maron, M., Robinson, J.G., et al. (2020). Net positive outcomes for nature. Nat. Ecol. Evol. *4*, 4–7.
9. Executive Secretary of the Convention on Biological Diversity (2022). 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. https://www.cbd.int/doc/c/16b6/e126/9d46160048cfcf74cadcf46d/wg2020-03-inf-11-en.pdf.
10. Díaz, S., Zafra-Calvo, N., Purvis, A., Verburg, P.H., Obura, D., Leadley, P., Chaplin-Kramer, R., De Meester, L., Dulloo, E., Martín-López, B., et al. (2020). Set ambitious goals for biodiversity and sustainability. Science *370*, 411–413.
11. Bolam, F.C., Mair, L., Angelico, M., Brooks, T.M., Burgman, M., Hermes, C., Hoffmann, M., Martin, R.W., McGowan, P.J.K., Rodrigues, A.S.L., et al. (2021). How many bird and mammal extinctions has recent conservation action prevented? Conserv. Biol. *14*, e12762.
12. Sumaila, U.R., Skerritt, D.J., Schuhbauer, A., Villasante, S., Cisneros-Montemayor, A.M., Sinan, H., Burnside, D., Raggi Abdalla, P., Abe, H., Addo, K.A., et al. (2021). WTO must ban harmful fisheries subsidies. Science *374*, 544.
13. Strassburg, B.B.N., Iribarrem, A., Beyer, H.L., Cordeiro, C.L., Crouzeilles, R., Jakovac, C.C., Junqueira, A.B., Lacerda, E., Latawiec, A.E., Balmford, A., et al. (2020). Global priority areas for ecosystem restoration. Nature *586*, 724–729.
14. Moreno-Mateos, D., Barbier, E.B., Jones, P.C., Jones, H.P., Aronson, J., López-López, J.A., McCrackin, M.L., Meli, P., Montoya, D.,

and Rey Benayas, J.M. (2017). Anthropogenic ecosystem disturbance and the recovery debt. Nat. Commun. *8*, 14163.

15. Mair, L., Bennun, L.A., Brooks, T.M., Butchart, S.H.M., Bolam, F.C., Burgess, N.D., Ekstrom, J.M.M., Milner-Gulland, E.J., Hoffmann, M., Ma, K., et al. (2021). A metric for spatially explicit contributions to science-based species targets. Nat. Ecol. Evol. *5*, 836–844.

16. Obura, D.O., Katerere, Y., Mayet, M., Kaelo, D., Msweli, S., Mather, K., Harris, J., Louis, M., Kramer, R., Teferi, T., et al. (2021). Integrate biodiversity targets from local to global levels. Science *373*, 746–748.

17. Xu, H., Cao, Y., Yu, D., Cao, M., He, Y., Gill, M., and Pereira, H.M. (2021). Ensuring effective implementation of the post-2020 global biodiversity targets. Nat. Ecol. Evol. *5*, 411–418.

18. Stevenson, S.L., Watermeyer, K., Caggiano, G., Fulton, E.A., Ferrier, S., and Nicholson, E. (2021). Matching biodiversity indicators to policy needs. Conserv. Biol. *35*, 522–532.