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Predicting the way forward for the Global Biodiversity Framework

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In order to truly look ahead and address pressing biodiversity challenges, the GBF needs a new international program that coordinates biodiversity research and modeling. We label this initiative the World Biodiversity Research Programme. Image credit: Shutterstock/SouthernCrx.

The meeting of the Convention on Biological Diversity (CBD) earlier this year was set up to propel the Kunming-Montreal Global Biodiversity Framework (GBF) (1) from agreement to action. As countries currently draft national action plans to meet the GBF's multiple targets to halt biodiversity loss and secure nature's contributions to people, this is our one chance to ask: will they put us on track to satisfy the GBF's long-term goals? And if not, how do we improve?

The answer to the first question is likely "no." The solution to the second is to expand the systematic use of predictive models in conservation biology. Otherwise, we will design ineffective strategies, misallocate limited resources, and not know whether our actions will work.

The GBF is a landmark agreement, with 23 targets aiming to restore ecosystems, protect species from extinction, and ensure equitable access to nature's benefits. Yet, as currently designed, it assesses the status and trends of biodiversity primarily through retrospective monitoring of indicators—such as the Red List index or the Living Planet index. Although this provides accountability by tracking past performance, it lacks forward-looking, predictive tools to evaluate whether current actions or new commitments can deliver desired outcomes. It is surprising, if not deeply concerning, that despite decades of advances in biodiversity modeling (2), the GBF

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overlooks the anticipatory power of these tools and does not mention "model" or "prediction" anywhere in its text.

This backward-looking approach risks the continued decline of global biodiversity by failing to provide timely warnings indicating that existing actions are insufficient to meet GBF goals. Without a clear connection from actions to outcomes, we believe there's a significant risk that the GBF will not achieve its ultimate goals, even if intermediate targets are met. The GBF needs to look forward, not just backward. We believe a new international program to coordinate biodiversity research and modeling, which we label the World Biodiversity Research Programme (WBRP), would go a long way toward this aim.

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The Importance of Prediction

Predictive biodiversity models use quantitative tools and simulations to forecast changes in key biodiversity components (3), such as genetic diversity, species distributions and abundances, and ecosystem services—under various scenarios of human activity and conservation interventions (4). These models range from statistical approaches such as correlative species distribution models to mechanistic models that incorporate biological processes such as physiology, demography, dispersal, and interspecific interactions (5). Importantly, predictive models can assess the impacts of alternative scenarios and identify which actions, such as habitat preservation or land-use regulations, can most effectively achieve national or global biodiversity goals.

Climate change models have advanced policy actions by comparing outcomes from alternative scenarios and providing guidance to set quantitative goals and deadlines for decarbonization (6). Similarly, biodiversity conservation managers and policymakers need predictive tools to identify the most effective combinations of actions to achieve their targets. By embracing predictive modeling, which integrates ecological, social, and economic data, the global biodiversity community can help countries develop innovative solutions, make informed decisions, and allocate resources efficiently (2).

Predictive models have already guided the successful management of threatened species (7), helped design reserves, and identified the worst invasive species (8). Globally, biodiversity models have been used to evaluate the impacts of future scenarios on biodiversity and ecosystem services (3, 4, 9), which framed the goals of the GBF. Despite these successes, the broader integration of predictive models into the GBF has yet to be achieved, likely due to limited coordination across the modeling community, underinvestment in global biodiversity research, persistent data gaps, unequal access to the necessary modeling infrastructure and expertise across countries, and, in some cases, limited trust in model results among policymakers and practitioners (2).

To stress the need for broader uptake, we outline key ways in which predictive models can significantly contribute. And to ensure rapid uptake and coordination, we argue for the creation of a new research program to encourage the use of predictive models in policy and practice and to accelerate progress toward the GBF targets and goals.

Modeling Solutions

Models can help in linking actions to outcomes. The GBF monitoring framework uses indicators to track progress toward its goals and targets, including mandatory headline indicators for national, regional and global monitoring and reporting and optional component and complementary indicators that cover different aspects of the goals and targets and allow more in-depth analyses of these. For example, target 4 (halting extinctions) uses the Red List Index, which tracks changes in extinction risk, as a headline indicator. It also uses the Living Planet Index, which shows trends in average vertebrate population size, as a component indicator, as well as the percentage of threatened species improving in status as a complementary indicator.

These indicators are derived from monitoring data and offer a necessary, but inherently retrospective, view of past changes. They highlight progress toward targets and goals but fall short of offering actionable insights on how to reach them. Predictive models, when linked with plausible future scenarios, can fill this gap. Models enhance the value of raw indicator data by uncovering cause-and-effect relationships between drivers and biodiversity and by projecting future biodiversity states under various scenarios.

This can maximize outcomes across interconnected targets and goals (10). For example, models can assess how expanding protected areas to meet target 3 (conserving at least 30% of land, waters, and seas) might affect progress toward target 4, given that increased land-use pressures outside protected areas could undermine conservation benefits by limiting connectivity to unprotected patches.

Accounting for Costs

It's important to account for economic and societal costs. Conservation actions often vary in effectiveness, costs, benefits, and broader impacts on other sectors. For example, achieving the target of preserving 30% of land can be approached in numerous ways, but the associated costs can vary dramatically, depending on land values and the socioeconomic effects on neighboring communities (11). Predictive models can maximize progress toward GBF goals and targets while reconciling societal needs and trade-offs between, for example, biodiversity, food production, health, and economic growth. Furthermore, models that integrate both social and economic costs and evaluate trade-offs between drivers (12) are critical to ensure each nation's ability to implement conservation actions effectively within their varied political and economic contexts.

Monitoring and assessment benefit from predictive models and vice versa. Models highlight data gaps and uncertainties and can guide the design of monitoring systems across ecosystems to better estimate indicators and trends (13). For example, models can show where and how often data should be collected to improve both the statistical robustness of estimated indicator trends and the predictive accuracy of models.

As researchers collect new data, models can be continuously updated to reduce uncertainty, test assumptions, and improve forecasts, creating an iterative learning cycle (5, 7). This tight feedback loop between monitoring and modeling enables adaptive management, meaning the timely reformulation of actions in response to changes in the predicted trajectory toward the target—for example, due to extreme environmental events, political disruptions, or novel drivers.

Bridging Scales

Predictive models can also estimate lag times between actions and responses, which span decades to even millennia and can leave lasting legacies (14). For example, populations might require years to recover after the introduction of hunting and fishing bans. These time lags imply that the effects of many actions might come after the 2030 deadline or too late for some species. Models can also help to plan the spatial and temporal coordination of conservation efforts. For example, wildlife managers can plan the reintroduction of threatened species based on predicted spread rates of the species.

Most conservation actions are local, but the impacts extend across larger scales and often transcend national boundaries. For example, multiple countries might implement restoration plans for threatened migratory species within their borders. But without coordination, these efforts risk underperforming because they do not link protective measures across national borders. Scaling from local to global actions can be done by linking models at different spatial scales.

The biodiversity crisis is a global challenge, yet many diverse regions remain poorly monitored and understudied, making reporting on indicators and applying predictive modeling particularly challenging. Insufficient capacity to formulate and implement National Biodiversity Strategies and Action Plans was cited as a major barrier for the 153 parties that had not submitted plans by the 2024 United Nations Biodiversity Conference of the Parties deadline. Through general insights and transfer learning, models can bridge local knowledge gaps and support decision-making by predicting both historical and future indicator trends. Predictive models developed in better-known regions can suggest strategies for data-poor regions. Critically, shared models can optimize future monitoring designs, while maximizing statistical power to reduce uncertainty in key components of indicators. As context-specific local knowledge and newly collected data from well-designed future monitoring programs (13, 15) become available, these models can be iteratively refined and action plans updated.

A Biodiversity Research Program

To coordinate international biodiversity research and drive further developments in predictive modeling and adaptive decision-support tools, the community needs a focused research agenda. This is what we've labeled the World Biodiversity Research Programme. Such an agenda would aid our understanding of biodiversity change and directly support the work and goals of the GBF.

The existing Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has been instrumental in summarizing the state of nature and providing policy support. However, its mandate is restricted to synthesizing existing research and assessing the evidence, rather than coordinating research efforts. This is also true for the Intergovernmental Panel on Climate Change. To fill this gap in climate science, the World Climate Research Programme (WCRP) coordinates international climate research and facilitates knowledge sharing. A WBRP can do the same job for biodiversity. As part of its work, it could then develop, evaluate, refine, and harmonize biodiversity models to support decision-makers working towards GBF goals.

For climate change, the WCRP administers the Coupled Model Intercomparison Project, which standardizes the inputs and outputs of climate models, serves as a central source for understanding and summarizing predictions about climate change and has helped drive continuous model improvements. A model intercomparison project for biodiversity could similarly design standardized modeling experiments and scenarios at multiple spatial scales to understand past, present, and future biodiversity changes in response to global drivers (3).

Also, a coordinated international effort is essential for ensuring equitable access to models and technical expertise for applying models by all parties to the agreement. Without a global organization to coordinate research and development, model-based decision support and scenarios risk reinforcing legacies of social and economic inequity present in biodiversity data (15). Developing global knowledge platforms (e.g., BON in a Box, https://boninabox.geobon.org/) and coordinating international efforts to improve model standardization could help bridge disparities in the parties' capacity to develop achievable, yet ambitious, goals, targets, and action plans to protect biodiversity and ecosystem services. Globally coordinated predictive models can bridge these gaps by guiding the development of cost-effective monitoring frameworks and action plans, thus empowering all parties to build capacity in these tools and achieve desired outcomes.

The climate change community has provided a roadmap for creating a global biodiversity research organization. The WCRP was established in 1980 as an international nongovernmental organization through joint sponsorship from the World Meteorological Organization, the International Council for Science, the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO), and occasional voluntary contributions from nations and donors. A WBRP could similarly be sponsored by the United Nations Environment Programme (UNEP), UNESCO, and development banks. UNEP already hosts the CBD secretariat and is well-positioned to initiate and oversee WBRP establishment.

Establishing such a program is not only feasible, but urgently needed to improve our predictive understanding of biodiversity and meet the ambitions of the GBF. It's clear that without predictive models and a way to develop their use in conservation, the GBF risks merely documenting ongoing biodiversity declines without helping to halt them. And that would mean writing nature's obituary—instead of its recovery.

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