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PERSPECTIVE

Conserving species' evolutionary potential and history: Opportunities under the Kunming–Montreal Global Biodiversity Framework

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Abstract

Genetic diversity (GD) and phylogenetic diversity (PD) respectively represent species' evolutionary potential and history, and support most of the biodiversity benefits to humanity. Yet, these two biodiversity facets have been overlooked in previous biodiversity policies. As the Parties to the Convention on Biological Diversity (CBD) adopted the Kunming–Montreal Global Biodiversity Framework (GBF) in December 2022, we analyze how GD and PD are considered in this new framework and discuss how their incorporation in the GBF could strengthen their conservation. Although the inclusion of certain indicators could be elevated, both GD and PD are an integral part of the recently adopted GBF. This represents a significant improvement compared to the CBD strategic plan 2011–2020 and an unprecedented opportunity to bring species' evolutionary potential and history to the core of public biodiversity policies. We urge the scientific community to leverage this opportunity to actually improve the conservation of species' evolutionary potential and history.

KEYWORDS

biodiversity policies, genetic diversity, multilateral environmental agreements, phylogenetic diversity, science–policy interface

1 | BACKGROUND

Genetic diversity (GD) quantifies the variation of genes within species, variation which occurs within and among populations (Hoban et al., 2022). GD therefore determines species' resilience and evolutionary potential, for example, their ability to adapt to changing environmental conditions (Sgrò et al., 2011). Higher GD within a species increases the chance of the species to adapt to new conditions. Inversely, lower GD within a species increases its risk of extinction (Spielman et al., 2004). GD also plays an important role in maintaining a variety of biodiversity benefits to humanity such as ecosystem resilience, food, medicine, energy, culture, and well-being (see Des Roches et al., 2021 for a review).

Phylogenetic diversity (PD) quantifies the evolutionary history captured by a set of species, as the sum of branch lengths connecting those species across the phylogenetic tree representing their evolutionary relationships (Faith, 1992). PD therefore represents the diversity of evolutionarily inherited features across the Tree of Life, which constitutes a reservoir of both current and yet-to-be discovered benefits for future generations—a notion referred to as biodiversity option value (IPBES, 2019). PD can best be maintained through prioritizing the conservation of evolutionarily distinct lineages to effectively safeguard the Tree of Life, such as those highlighted within the EDGE (Evolutionarily Distinct and Globally Endangered) species framework (Gumbs et al., 2023).

GD and PD respectively represent species' evolutionary potential and history, and support most of the biodiversity benefits to humanity. In addition, both GD and PD are impacted by unprecedent levels of human-induced global change, and are expected to be even more impacted in the future (e.g., Exposito-Alonso et al., 2022; Jono & Pavoine, 2012; Li et al., 2019; Theodoridis et al., 2021). Yet, these two biodiversity facets have been overlooked in previous biodiversity policies (Cook & Sgrò, 2017; Hoban, Campbell, et al., 2021; Robuchon et al., 2021). Specifically, while PD was fully excluded from the strategic plan 2011–2020 of the Convention on Biological Diversity (CBD), GD was recognized (e.g., Aichi Target 13) but interpreted narrowly (Hoban, Campbell, et al., 2021), mainly addressing GD of domesticated species (only a small fraction of all species). Moreover, many countries neglected to develop monitoring strategies with adequate indicators for GD and/or largely focused on *ex situ* conservation, overlooking *in situ* actions (Hoban et al., 2020). This was partly due to the fact that the information regarding how (and why) to conserve and monitor GD in practice was inaccessible to policymakers and managers, and partly due to lack of GD indicators (Cook & Sgrò, 2017; Hoban et al., 2013; Hoban, Campbell, et al., 2021; Taylor et al., 2017). However, the situation has recently changed. For PD, the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES) now recognizes PD as an indicator of "maintenance of options" and "medicinal, biochemical and genetic resources" (IPBES, 2019). For GD, numerous recent advances in knowledge, technology, databases, practice, and capacity now make global commitments for conserving and monitoring GD feasible (Hoban, Bruford, et al., 2021). As the Parties to the CBD met in December 2022 in Montreal and adopted the Kunming–Montreal Global Biodiversity Framework (GBF), we briefly analyze how GD and PD are currently considered in this new framework and discuss the opportunities this brings for strengthening their conservation.

2 | GENETIC AND PHYLOGENETIC DIVERSITY IN THE KUNMING–MONTREAL GLOBAL BIODIVERSITY FRAMEWORK

We screened the adopted Kunming–Montreal GBF[1] to examine whether GD and PD are mentioned in Goals or Targets (see Box 1 for explanation of these terms and the hierarchical nature of the GBF). Although PD was not mentioned once, we found two instances of GD:

- once under the 2050 Goal A ("The integrity, connectivity and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050; human induced extinction of known threatened species is halted, and, by 2050, the extinction rate and risk of all species are reduced tenfold and the abundance of native wild species is increased to healthy and resilient levels; the *genetic diversity* within populations of wild and domesticated species, is maintained, safeguarding their adaptive potential"); and,
- once under the 2030 Target 4 ("Ensure urgent management actions to halt human induced extinction of known threatened species and for the recovery and conservation of species, in particular threatened species, to significantly reduce extinction risk, as well as to maintain and restore the *genetic diversity* within and between populations of native, wild and domesticated species to maintain their adaptive potential, including through *in situ* and *ex situ* conservation and sustainable management practices, and effectively manage human–wildlife interactions to minimize human-wildlife conflict for coexistence").

BOX 1 Hierarchical structure of the Kunming–Montreal GBF and its monitoring system

The Kunming–Montreal GBF has four **2050 Goals** related to the 2050 Vision for Biodiversity: "By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people," and 23 **2030 Targets**[1]. To track and assess progress toward the **2050 Goals** and **2030 Targets**, a monitoring system with three types of indicators has been developed[2]. **Headline indicators** are high-level indicators which capture the overall scope of the **2050 Goals** and **2030 Targets** of the Kunming–Montreal GBF, to be used for planning and tracking progress. They are nationally, regionally and globally relevant indicators validated by Parties. **Component indicators** are optional indicators that, together with the headline indicators, inform specific components of each **2050 Goal** and **2030 Target** of the Kunming–Montreal GBF (Goals and Targets can be very broad in scope and therefore divided into several subgoals or subtargets referred as components) which may apply at the global, regional, national and subnational level. **Complementary indicators** are optional indicators for thematic or in-depth analysis of each **2050 Goal** and **2030 Target** which may be applicable at global, regional, national, and subnational levels.

We further screened the monitoring framework for the Kunming–Montreal GBF[2] to investigate whether any GD or PD indicators were included. Specifically, we examined whether the indicators proposed by Hoban et al. (2020) and the Coalition for Conservation Genetics (Kershaw et al., 2022) for GD and those proposed by the IUCN Species Survival Commission's Phylogenetic Diversity Task Force[3] (PDTF) for PD were included in the draft monitoring framework. The three indicators proposed for GD are: (i) the number of populations within species with effective population size (Ne) above 500 versus those with Ne below 500, (ii) the proportion of distinct populations maintained within species, and (iii) the number of species and populations in which genetic diversity is being monitored using DNA-based methods. Among these three indicators proposed for GD, the first two indicators are included in the monitoring framework for the Kunming–Montreal GBF (Table 1). The first indicator is included as a headline indicator (see Box 1 for an explanation of the different indicator types) to inform Goal A and Target 4. The second one is included as complementary indicator for Goal A. Importantly, the third indicator—which is the only one assessing GD monitoring using DNA-based methods—is not included. This third indicator is nonetheless relevant to Target 4, because GD studies often inform active management actions that support species and genetic conservation and recovery (Bolam et al., 2022; Hoban, Bruford, et al., 2021). These three indicators were recently demonstrated to be feasible for reporting genetic status for thousands of species at a national scale in Sweden (Thurfjell et al., 2022), using available nongenetic data (e.g. population sizes, historic maps) in national biodiversity agencies for the first two indicators, and published reviews on genetic studies of species for the third. The indicators are currently undergoing further testing in Japan, South Africa, Mexico, Sweden, Colombia, Belgium, France, Australia, and United States (Hoban, Mastretta-Yanes, and da Silva, personal comm.). Beyond the three GD indicators proposed by Hoban et al. (2020) and the Coalition for Conservation Genetics, four other GD indicators are included in the monitoring framework for the Kunming–Montreal GBF (Table 1): number of plant and animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities (usually the size of seed and gene banks—often the number of accessions held), proportion of local breeds classified as being at risk of extinction, comprehensiveness of conservation of socioeconomically as well as culturally valuable species (the proportion of the species' geographic range that has been sampled for *ex situ* conservation, or the proportion covered by protected areas), and genetic scorecard for wild species. Note that several of these cover *ex situ* conservation efforts, and are affordable to calculate.

Regarding the two PD indicators proposed by the PDTF, namely (i) expected loss of PD (also used in IPBES, 2019) and (ii) the changing status of Evolutionarily Distinct and Globally Endangered species (EDGE index), they are both included in the monitoring framework for the Kunming–Montreal GBF (Table 1). The expected loss of PD is included as a complementary indicator to inform 2050 Goal A and Goal B ("Nature's contributions to people have been valued, maintained or enhanced through conservation and sustainable use supporting the global development agenda for the benefit of all"), and the EDGE index as a complementary indicator to inform 2030 Target 4 and as a component indicator to inform 2050 Goal A. These two indicators explicitly link benefits from biodiversity measured by PD under Goal B,

TABLE 1 Genetic and phylogenetic diversity indicators adopted for the Kunming–Montreal Global Biodiversity Framework presented by goal, target and indicator type.

	2050 Goals	2030 Targets
Genetic diversity (GD) indicators		
Proportion of populations within species with an effective population size >500	Headline indicator for Goal A	Headline indicator for Target 4
Proportion of populations maintained within species	Complementary indicator for Goal A	
Number of plant and animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities	Complementary indicator for Goal A	• Component indicator for Target 4 • Complementary indicator for Target 9
Proportion of local breeds classified as being at risk of extinction	Complementary indicator for Goal A	• Complementary indicator for Target 4 • Complementary indicator for Target 10
Comprehensiveness of conservation of socioeconomically as well as culturally valuable species	Complementary indicator for Goal A	
Genetic scorecard for wild species	Complementary indicator for Goal A	
Phylogenetic diversity (PD) indicators		
Expected loss of phylogenetic diversity	• Complementary indicator for Goal A • Complementary indicator for Goal B	
Changing status of evolutionary distinct and globally endangered species (EDGE Index)	Component indicator for Goal A	Complementary indicator for Target 4

with monitoring the conservation of evolutionarily distinctive species under Goal A. The two proposed indicators can demonstrably be produced at the global and national level for multiple taxonomic groups (Gumbs et al., 2021; IPBES, 2019), and the PDTF have committed to producing these indicators on a regular basis to reduce the reporting burden on Parties (Gumbs et al., 2021).

3 | OPPORTUNITY TO STRENGTHEN THE CONSERVATION OF SPECIES' EVOLUTIONARY POTENTIAL AND HISTORY

Unlike the CBD strategic plan 2011–2020, GD and PD are now both considered in the Kunming–Montreal GBF. Their inclusion could have been even greater, for instance by specifying numerical targets for conserving GD (as in the first draft of the post-2020 GBF[4] proposing to maintain 90 percent of GD within all species under 2050 Goal A), by including the third GD indicator on the number of species and populations in which genetic diversity is being monitored using DNA-based methods (at least as a complementary indicator, to avoid concerns about the availability of data), and by adopting at least one of the PD indicators as a headline indicator (which is the only indicator type compulsory to report). There may still be room for this latter point, as the headline indicator "services provided by ecosystems" adopted under 2050 Goal B misses an agreed up to date methodology that will need to be developed before 2025, and the indicator Expected loss of PD may be used there to represent either or both "maintenance of options" and "medicinal, biochemical and genetic resources." Nonetheless and independently of the adoption of Expected loss of PD as headline indicator, the current inclusion of GD and PD in the adopted Kunming–Montreal GBF represents a significant improvement compared to the CBD strategic plan 2011–2020 and an unprecedented opportunity to bring species' evolutionary potential and history to the core of public biodiversity policies. Moreover, GD and PD capture nonmarket values of biodiversity, and mainstreaming these non-market values is necessary to achieve transformative change (IPBES, 2022). For instance, while GD embodies strong intrinsic values as it determines the possibility of the species to survive to new conditions, PD captures a relational value of biodiversity that supports the intergenerational equity principle of the Kunming–

Montreal GBF—representing both current and yet-to-be discovered biodiversity benefits for future generations—which is otherwise neglected in Goal B.

However, this policy opportunity is necessary but not sufficient to effectively protect species' evolutionary potential and history. Whether this would happen largely depends on the implementation of the Kunming–Montreal GBF targets by the 196 Parties to the CBD, including the European Union. Parties now need to revise and update their national biodiversity strategies and action plans following the adoption of the Kunming–Montreal GBF to include measures to reach its targets, and this ahead of the next Conferences of Parties to the CBD (COP16) planned in 2024 in Turkey. This may require changes in policies, legislation and incentives as well as improved monitoring to report on the above-mentioned GD and PD indicators at the national level—at least those adopted as headline indicators. Some legislation is already poised for this—for example, the "favourable conservation status" targeted for species under the EU Birds[5] and Habitats[6] Directives is compatible with the first GD indicator on effective population size while Canada's Species At Risk Act[7] protects genetically distinct populations, which is compatible with the second GD indicator on the proportion of distinct populations maintained within species. Further policy work will need to be followed closely, and supported by scientists, in the coming years.

4 | THE ROLE OF THE SCIENTIFIC COMMUNITY

The incorporation of GD and PD in the Kunming–Montreal GBF results from recent advances in knowledge, technology and databases on GD and PD, and from an unprecedented mobilization of the scientific community in both academia and NGOs in bringing this information to the attention of policymakers. Indeed, these scientists have organized themselves into groups—the Coalition for Conservation Genetics (Kershaw et al., 2022) for GD and the IUCN Species Survival Commission's Phylogenetic Diversity Task Force[8] for PD—that supported the Kunming–Montreal GBF by providing feedback on its drafts, advocating for the importance of recognizing GD and PD as important biodiversity components and for the benefits to humanity, as well as developing and proposing indicators for its monitoring approach. This is a great achievement, but the role of the scientific community should not end here.

Now that GD and PD are included in the Kunming–Montreal GBF, the scientific community will first need to ensure that adopted GD and PD indicators meet the quality, operationality and transparency criteria listed in the monitoring framework for the Kunming–Montreal GBF by 2025. Second, the scientific community will need to transform this policy opportunity into actual conservation practice by applying the associated metrics into operational conservation and monitoring actions, working with and for the practitioners. The good news is that research on how to best conserve GD and PD is flourishing (e.g., Gumbs et al., 2023; Kershaw et al., 2022; Robuchon et al., 2021 and references therein), and concrete conservation or monitoring programs have already been developed, whether it is for GD (e.g., Mapping and monitoring genetic diversity in Sweden[9]) or for PD (the Zoological Society of London's EDGE of Existence Programme[10]). The scientific community must also make specific, pragmatic and clear policy recommendations (see Frankham, 2022 for an example, or IUCN's recent "Selecting species and populations for monitoring of genetic diversity"). These efforts need to be increased to ensure that these two fundamental facets of biodiversity are no longer overlooked. The scientific community must also communicate their knowledge effectively both with the practitioners carrying out monitoring programs on the ground and with those reporting on targets of the Kunming–Montreal GBF by using the appropriate channels. Concretely, this could be achieved by engaging with the Global Knowledge Support Service for Biodiversity[11] adopted by the Parties to the CBD in parallel to the Kunming–Montreal GBF, a service currently still in the making to help the Parties in implementing the Kunming–Montreal GBF. Hence, we conclude that the scientific community *must* engage, collaborate, and leverage the opportunity offered by the recently adopted Kunming–Montreal GBF to improve the conservation of species' evolutionary potential and history!

AUTHOR CONTRIBUTIONS

MR conceptualized this perspective, built the network of co-authors, and led the writing during both the original draft preparation and review stages. All other co-authors contributed to review and edit the original draft and the revised version based on their own field of expertise.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

No data were used for this work.

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ENDNOTES

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