Conserving species' evolutionary potential and history: opportunities under the new post-2020 global biodiversity framework

Marine Robuchon[1], Jessica da Silva[2,3], Grégoire Dubois[4], Rikki Gumbs[5], Sean Hoban[6,7], Linda Laikre[8], Nisha R. Owen[9], and Andrea Perino[10]

[1]Affiliation not available
[2]South African National Biodiversity Institute, Kirstenbosch Research Centre, Cape Town, South Africa
[3]Centre for Ecological Genomics and Wildlife Conservation, Department of Zoology, University of Johannesburg, South Africa
[4]Joint Research Centre (JRC) of the European Commission, Directorate for Sustainable Resources, 21027 Ispra (VA), Italy
[5]EDGE of Existence programme, Conservation and Policy, Zoological Society of London, London, UK, NW1 4RY
[6]The Center for Tree Science, The Morton Arboretum, 60532, Lisle, USA
[7]Committee on Evolutionary Biology, The University of Chicago, Chicago, USA
[8]Department of Zoology, Division of Population Genetics, Stockholm University, SE10691 Stockholm, Sweden
[9]On the Edge Conservation, London, SW3 2ND, UK
[10]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Deutscher Platz 5e, 04103 Leipzig, Germany

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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 plan to meet in December 2022 to agree on a new post-2020 global biodiversity framework (GBF), we analyse how GD and PD are considered in this new framework and discuss how this could strengthen their conservation. Although their inclusion could be larger, both GD and PD are currently considered in the first draft of the post-2020 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.

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, e.g. 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 prioritising the conservation of evolutionarily distinct lineages to effectively safeguard the Tree of Life, such as the those highlighted within the EDGE (Evolutionarily Distinct and Globally Endangered) species framework (Gumbs et al., 2022).

GD and 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 (Cook & Sgrò, 2017; Hoban 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 recognised (e.g. Aichi Target 13) but interpreted narrowly (Hoban 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., 2021; Hoban et al., 2013; Taylor et al., 2017). However, the situation has recently changed. For PD, the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES) now recognises 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 et al., 2021). As the Parties to the Convention on Biological Diversity (CBD) plan to meet in December 2022 in Montréal to agree on a new post-2020 global biodiversity framework (GBF), we briefly analyse how GD and PD are currently considered in this new framework and discuss the opportunities this brings for strengthening their conservation.

Genetic and phylogenetic diversity in the draft post-2020 global biodiversity framework

We screened the zero, 0.5, and first drafts of the post-2020 GBF to examine whether GD and PD are mentioned in Goals, Milestones or Targets (see Box 1 for explanation of these terms and the hierarchical nature of the GBF). Focusing on the first draft (CBD/WG2020/3/3), although PD was not mentioned once, we found five instances of GD:

- twice under the 2050 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 per cent of *genetic diversity* within all species maintained");
- twice under the 2030 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"); and,
- once under the 2030 Action 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").

We screened two further documents to investigate whether any GD or PD indicators were included in the post-2020 GBF draft monitoring framework: (i) the proposed monitoring approach and headline, component and complementary indicators from the third Open-Ended Working Group (OEWG-3) (CBD/WG2020/3/INF/2) and (ii) the latest report from an expert workshop on the proposed indicators held in Bonn, Germany (CBD/ID/OM/2022/1/2). 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 (PDTF) for PD were included in the draft monitoring framework. We found that among the three indicators proposed for GD - namely (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 - the first two indicators are included in the proposed monitoring approach and headline, component and complementary indicators of the post-2020 GBF (Table 1). The first indicator is included as a headline indicator to inform Goal A (and previously recognised Milestone A.3), and is a recommended component indicator for Target 4. The second one is included as a possible component indicator for Goal A. These first two indicators are also included in the latest report from an expert workshop on the post-2020 GBF (Table 1). Importantly, the third indicator – which is the only one assessing GD monitoring using DNA based methods – is not included (Table 1). This third indicator is 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 et al., 2021). These indicators were recently demonstrated to be feasible for reporting genetic status for thousands of species at a national scale by Sweden (Thurfjell et al., 2022) using available non-genetic data (e.g. population sizes, historic maps) in national biodiversity agencies. The indicators are currently undergoing further testing in Japan, South Africa, Mexico, Sweden, Columbia, Belgium, France, Australia, and USA (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 proposed monitoring approach and headline, component and complementary indicators of the post-2020 GBF and/or in the latest report from an expert workshop on the post-2020 GBF (Table 1).

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 proposed monitoring approach and headline, component and complementary indicators of the post-2020 GBF (Table 1). The expected loss of PD is included as a complementary indicator to inform 2050 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 Action Target 4 and 2050 Goal A. They are also included in the latest report from an expert workshop on the post-2020 GBF (Table 1). These two indicators explicitly link benefits from biodiversity measured by PD under Goal B, 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 (IPBES, 2019; Gumbs et al., 2021), and the PDTF has committed to producing these indicators on a regular basis to reduce the reporting burden on Parties (Gumbs et al., 2021).

Opportunity to strengthen the conservation of species' evolutionary potential and history
Unlike the CBD strategic plan 2011-2020, GD and PD are now considered in the draft text for the post-2020 GBF. While their inclusion could be larger (e.g., including the third GD indicator, adopting the PD indicators as headline indicators), 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. Moreover, GD and PD capture non-market 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 ensures intergenerational equity – representing both current and yet-to-be discovered biodiversity benefits – 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 depends on (i) the actual inclusion of GD and PD into the final, adopted post-2020 GBF and (ii) the implementation of its targets by the 196 Parties to the CBD, including the European Union. Parties will need to revise and update their national biodiversity strategy action plans following the adoption of the post-2020 GBF to include measures to reach its targets. 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 that will be adopted as headline indicators. Some legislation is already poised for this – for example, the 'favourable conservation status' targeted for species under the EU Birds and Habitats Directives is compatible with the first GD indicator on effective population size while Canada's Species At Risk Actprotects 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.

The role of the scientific community

Incorporating GD and PD in the draft post-2020 GBF results from recent advances in knowledge, technology and databases on GD and PD, and from an unprecedented mobilisation of the scientific community in both academia and NGOs in bringing this information to the attention of policymakers. Indeed, these scientists have organised themselves into groups – the Coalition for Conservation Genetics (Kershaw et al., 2022) for GD and the IUCN Species Survival Commission's PTDF for PD – that supported the post-2020 GBF by providing feedback on its drafts, advocating for the importance of recognising 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.

First, the scientific community needs to keep advocating for the inclusion of GD and PD into the post-2020 GBF, to ensure that these two biodiversity facets are actually included in the final GBF to be adopted in December 2022 – and we hope that this paper will contribute to reach that goal. Second, assuming that GD and PD are included in the post-2020 GBF, 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. (Robuchon et al., 2021; Gumbs et al., 2022; Kershaw et al., 2022); 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) or for PD (the Zoological Society of London's EDGE of Existence Programme). 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. Hence, we conclude that the scientific community *must* engage, collaborate, and leverage the opportunity offered by the new post-2020 GBF to improve the conservation of species' evolutionary potential and history!

Box 1 – Hierarchical structure of the post-2020 GBF and its monitoring system

The post-2020 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 22 or 23 **2030 Action Targets** for urgent action over the decade to 2030[1]. To track and assess progress towards the **2050 Goals** and **2030 Action 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 Action Targets** of the post-2020 GBF, which

must be used for tracking national progress, as well as for tracking regional and global progress. They are nationally relevant indicators for use by all Parties, and at regional and global levels. In addition, headline indicators could constitute one of the main reporting elements of the national reports and support national planning processes. **Components indicators** are for monitoring each component of each **2050 Goal** and **2030 Action Target** of the post-2020 GBF (rather than directly the **2050 Goals** or **2030 Action Targets**) at national, regional and global level. Parties are encouraged to use these indicators for national reporting and relevant planning processes. **Complementary indicators** are for thematic or in-depth analysis of each **2050 Goal** and **2030 Action Target**. They may be applicable at global, regional and national levels[3] .

Table 1. Progress regarding the proposed genetic and phylogenetic indicators in the preparation of the post-2020 Global Biodiversity Framework.

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*A recommendation during the third Open-ended Working Group (OEWG-3) was to collapse Milestones into either Goals or Targets, and hence they are being dissolved from the GBF hierarchical structure.

[1] https://www.cbd.int/doc/c/2c69/df5a/01ee87752c3612d3ba7ec341/wg2020-02-03-add1-en.pdf

[2] https://www.cbd.int/doc/c/705d/6b4b/a1a463c1b19392bde6fa08f3/sbstta-24-03-en.pdf

[3] https://www.cbd.int/doc/c/437d/a239/12a22f2eaf5e6d103ed9adad/wg2020-03-inf-02-en.pdf

[4] https://www.cbd.int/doc/c/3190/c3f4/1d9fe2d2dedc8c8b97023750/id-om-2022-01-02-en.pdf

References

Global genetic diversity status and trends: towards a suite of Essential Biodiversity Variables (EBVs) for genetic composition. (2022). *Biological Reviews*, *97*(4), 1511–1538. https://doi.org/10.1111/brv.12852

Building evolutionary resilience for conserving biodiversity under climate change. (2011). *Evolutionary Applications*, *4*(2), 326–337. https://doi.org/10.1111/j.1752-4571.2010.00157.x

Most species are not driven to extinction before genetic factors impact them. (2004). *Proceedings of the National Academy of Sciences*, *101*(42), 15261–15264. https://doi.org/10.1073/pnas.0403809101

Conserving intraspecific variation for nature's contributions to people. (2021). *Nature Ecology and Evolution*, *5*(5), 574–582. https://doi.org/10.1038/s41559-021-01403-5

Conservation evaluation and phylogenetic diversity. (1992). *Biological Conservation*, *61*(1), 1–10. https://doi.org/10.1016/0006-3207(92)91201-3

Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2019). Brondizio, Eduardo; Diaz, Sandra; Settele, Josef; Ngo, Hien T. https://zenodo.org/record/5657041

EDGE2: advancing the prioritisation of threatened evolutionary history for conservation action. (2022). https://doi.org/10.1101/2022.05.17.492313

Aligning science and policy to achieve evolutionarily enlightened conservation. (2017). *Conservation Biology*, *31*(3), 501–512. https://doi.org/10.1111/cobi.12863

Genetic diversity is considered important but interpreted narrowly in country reports to the Convention on Biological Diversity: Current actions and indicators are insufficient. (2021). *Biological Conservation*, *261*, 109233. https://doi.org/10.1016/j.biocon.2021.109233

Revisiting species and areas of interest for conserving global mammalian phylogenetic diversity. (2021). *Nature Communications*, *12*(1). https://doi.org/10.1038/s41467-021-23861-y

Genetic diversity targets and indicators in the CBD post-2020 Global Biodiversity Framework must be improved. (2020). *Biological Conservation*, *248*, 108654. https://doi.org/10.1016/j.biocon.2020.108654

Bringing genetic diversity to the forefront of conservation policy and management. (2013). *Conservation Genetics Resources*, *5*(2), 593–598. https://doi.org/10.1007/s12686-013-9859-y

Bridging the conservation genetics gap by identifying barriers to implementation for conservation practitioners. (2017). *Global Ecology and Conservation*, *10*, 231–242. https://doi.org/10.1016/j.gecco.2017.04.001

Global Commitments to Conserving and Monitoring Genetic Diversity Are Now Necessary and Feasible. (2021). *BioScience*, *71*(9), 964–976. https://doi.org/10.1093/biosci/biab054

Over half of threatened species require targeted recovery actions to avert human-induced extinction. (2022). *Frontiers in Ecology and the Environment*. https://doi.org/10.1002/fee.2537

Practical application of indicators for genetic diversity in CBD post-2020 global biodiversity framework implementation. (2022). *Ecological Indicators*, *142*, 109167. https://doi.org/10.1016/j.ecolind.2022.109167

The Post-2020 Global Biodiversity Framework must safeguard the Tree of Life. (2021). https://doi.org/10.1101/2021.03.03.433783

Methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2022). Balvanera, Patricia; Pascual, Unai; Christie, Michael; González-Jiménez, David. https://zenodo.org/record/6522523

The Coalition for Conservation Genetics: Working across organizations to build capacity and achieve change in policy and practice. (2022). *Conservation Science and Practice*, *4*(4). https://doi.org/10.1111/csp2.12635

Evaluation of proposed genetic goals and targets for the Convention on Biological Diversity. (2022). *Conservation Genetics*, *23*(5), 865–870. https://doi.org/10.1007/s10592-022-01459-1