comment

Include biodiversity representation indicators in area-based conservation targets

Advances in spatial biodiversity science and nationally available data have enabled the development of indicators that report on biodiversity outcomes, account for uneven global biodiversity between countries, and provide direct planning support. We urge their inclusion in the post-2020 global biodiversity framework.

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In 2022, parties to the Convention on Biological Diversity (CBD) will assemble in Kunming, China to agree on the post-2020 global biodiversity framework[1] (GBF). Addressing threats that contribute to species extinctions and affect their role in ensuring ecosystem integrity underpins the GBF's overarching Goal A, which stipulates "healthy and resilient populations of all species" and "reduced extinction rates". Although multiple actions are needed to safeguard biodiversity, establishing targets for protected areas and other effective area-based conservation measures (OECMs) is recognized as a primary mechanism to achieve Goal A.

The previous CBD framework's Aichi Target 11 aspired to reach 17% of lands and 10% of oceans in protected areas by 2020. Although it prompted significant protected area expansion[2,3], collective efforts ultimately fell short of delivering the expected outcomes for biodiversity[4]. Disparities across nations in political will and capacity to administer conservation meant progress towards targets varied widely[2]. These failures have exposed the risk of focusing on a target that is an action (such as expanding protected areas) rather than focusing on the desired outcome of halting biodiversity loss[5–7]. However, the simplicity of a common goal of protected area percentage remains an expedient strategy to galvanize support for biodiversity conservation. Acknowledging this power, we argue that inclusion of metrics addressing biodiversity conservation outcomes is critical for ensuring that the fundamental objectives of Goal A are met. To achieve this, we recommend the Species Protection Index (SPI), jointly with the associated draft GBF headline indicator Species Habitat Index (SHI) be included as headline indicators. Collectively, we represent individual perspectives from conservation policy guidance (H.P.P.), advocacy (B.O'D.), science-driven planning (J.McG. and P.V.), national implementation (M.C.L.-M.) and biodiversity indicator development (W.J. and D.S.R.). We are concerned that measuring coverage of area alone, or of key 'important' areas, disregards advances in biodiversity science that have been made since the pre-2010 inception of the previous framework and ignores spatial planning principles known to deliver superior conservation outcomes through adequate representation.

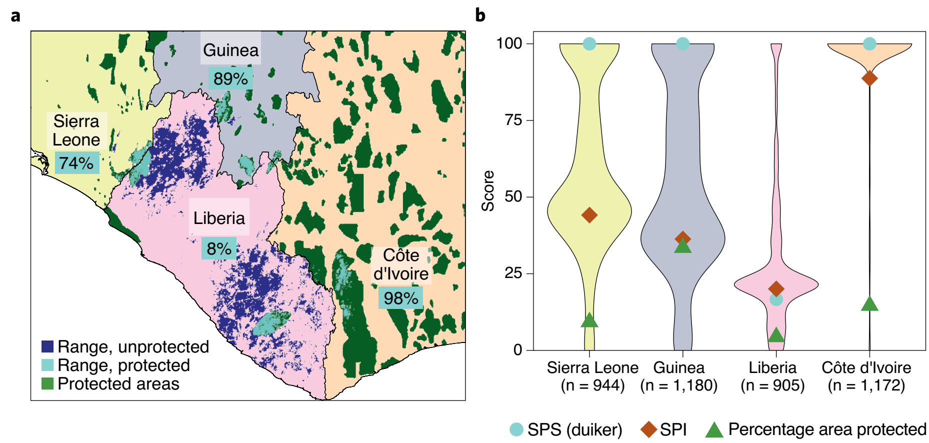

Fig. 1 | Measuring the transboundary nature of area-based biodiversity conservation. a, Distribution and protection of the zebra duiker (*Cephalophus zebra*), a rainforest specialist threatened by habitat loss (https://mol.org/species/protect/Cephalophus_zebra). The map shows global, habitat-suitable range by country[11], with Liberia holding the greatest portion (stewardship), and the variation in assumed national range portions protected. Basic formulas suggest 48% of global range as adequate conservation area representation for this species. **b**, SPI values by country (orange) derived from the individual Species Protection Scores (SPS) for the zebra duiker (cyan) and all assessed species (violin plots) in relation to protected area coverage (green). The SPS reflects the percentage of area representation target achieved within a country for a given species. Across assessed species, a country's SPI is given as the average SPS, weighted by their respective stewardship (country-endemic species weigh most). SPI values range from 0 and 100, where a value of 50 means that on average species are half-way to sufficient representation in conservation areas. Depending on how effectively conservation areas represent species, national SPI scores are strongly or only slightly larger than the percentage of national area protected. Violin plots show variation of SPS values within and among countries for all assessed species (n = count of in-country species included). In this example, the duiker range portion protected in Liberia is below the adequacy target, resulting in a suboptimal SPS value (8%/48% = 16.7). See Supplementary Information for data calculations and other details and note that the indicator can be supplemented or directly calculated with nationally held data.

The SPI and SHI are part of a new generation of data-driven, species-level indicators that support measurement, assessment and decision-support at both national and global scale. The two indicators were developed under the auspices of the GEO Biodiversity Observation Network and are peer-reviewed members of the core indicator suite recently used in global and regional assessments by the

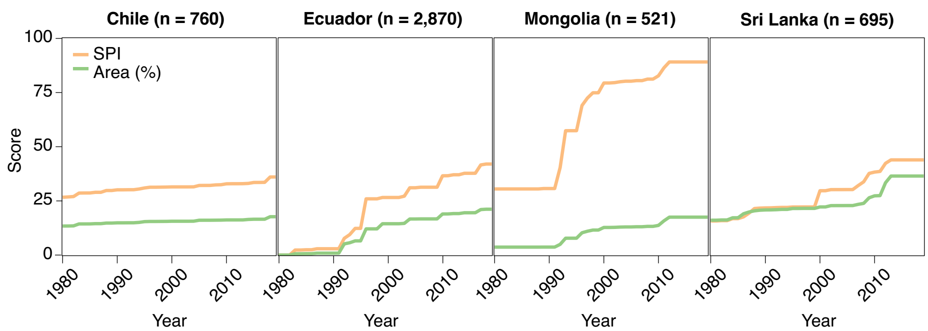

Fig. 2 | Example of four countries with differing divergence in protected area coverage and biodiversity outcomes as measured by the country SPI for terrestrial vertebrates. Biodiversity outcomes might appear simply commensurate with areal additions (Chile), exceed chance expectation (Ecuador and Sri Lanka), or be particularly large in relation to conservation area added (Mongolia, a country that has embraced spatial conservation planning to achieve better biodiversity representation in its protected areas[29]). See Fig. 1 and Supplementary Information for detailed explanation of the SPI and calculations. (n = count of in-country species included).

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and in other conservation and science reporting[8–11]. With parties to the CBD currently finalizing specific headline indicators jointly with the targets and goals for the next ten years, we urge that legacy indicators be complemented by new indicators to orient the global monitoring framework towards more meaningful biodiversity measures.

The '30x30' vision

Following ambitious, longer-term visions[12], broad consensus is emerging for a global target to conserve 30% of the planet's lands and oceans by 2030; 63 countries have already pledged to support this target following the Kunming meeting (https://www.hacfornatureandpeople.org), and the target is included in the draft GBF's Target 3: "Ensure that at least 30 per cent globally of land areas and of sea areas, especially areas of particular importance for biodiversity and its contributions to people, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes." (We support a language revision that explicitly addresses freshwater systems, currently under discussion.)

Without clear reference to Goal A's aspiration of biodiversity outcomes, many countries may commit to an areal percentage global target and then transfer that commitment to an equivalent percentage of their areas of jurisdiction (for example, 30% of national lands and waters). This was what happened under Aichi Target 11 of the previous framework, which was similarly ambiguous about what each nation should contribute. For example, the USA has proactively adopted a '30x30' target for its own lands and waters, as did the state of California, the UK, Canada, the European Union and others[9]. Although these are remarkable commitments, the objectives of Goal A suggest that nations should use global biodiversity outcomes to guide area-based conservation decisions, rather than internationally uniform area percentages. Crucially, despite the expectation for "ecologically representative" conservation areas in the target language, there are presently no headline indicators to ensure this aspiration.

An uneven challenge

Although some responsibilities are inherently globally shared — such as greenhouse gases, for which each country's absolute emission reduction offers comparable climate benefits — such equivalency does not apply to biodiversity. Almost half of the approximately 32,000 extant terrestrial vertebrate species are restricted to single countries[9]. Just 20 nations hold more than three-quarters of these single-country endemics, while most harbour fewer than 10 of them each. For the other half of terrestrial vertebrates, stewardship is shared across almost nine countries on average (median = 4). For example, the future of the threatened zebra duiker (*Cephalophus zebra*) depends on the policies and actions of four different countries (Fig. 1a).

The uneven and transboundary nature of biodiversity requires recognition of cross-national complementarity in governance and action frameworks[13–15]. This need for international collaboration is intensified by the uneven capacity of developing countries, which hold some of the greatest biodiversity, to invest in effectively protecting it[14,16]. Addressing these financing and capacity gaps and ensuring land rights and enhanced local livelihoods is critical to an outcome-focused biodiversity agenda. But so is identifying consistent indicators of progress that account for the uneven distribution of benefits within and across national area-based conservation strategies.

Add area, but measure outcomes

The central role of relevant measurements of progress is recognized in the GBF monitoring framework (CBD/SBSTTA/24/3)[17], which aims to identify comparable global indicators that closely link goals and targets. Current metrics — such as percentage 'country area' or 'key' or 'important' area conserved — measure conservation progress in a binary way that has limited links to biodiversity outcomes and ignores incremental contributions. To achieve the biodiversity outcomes of Goal A through Target 3's area-based conservation agenda, addressing adequate representation of biodiversity is critical[14,18,19]. Representation is one of the most fundamental principles in conservation that ensures all biodiversity receives attention[18], with adequacy guaranteeing that the spatial conservation coverage of species is enough to support their viability and ecological role[5]. Fortunately, new data and approaches are increasingly enabling such outcome-focused measurement via essential biodiversity variables (EBVs): core information based on standardized workflows that link to independent national monitoring and data collected across a range of scales[20]. Specifically, species population EBVs — developed through increasingly detailed and taxonomically extensive species data, near-global remote sensing and novel modelling methodology — allow the assessment of the contribution to adequate representation provided by any new area-based management[10].

The SPI is a metric that uses EBV-derived information to assess adequate biodiversity representation, based on the change in coverage of a species' range that is located in protected areas and/or OECMs[5,21] and the significance of such national contributions for global biodiversity conservation (Fig. 1b; and see Supplementary Information for more details on the SPI). The indicator could be adapted to include ecosystems that are insufficiently characterized by species data or to address other facets of biodiversity[5,21].

When measured alongside traditional area-based indicators, such as trajectories in percentage protected area, the SPI helps quantify the representation provided by area-based conservation to safeguard biodiversity. The four examples provided in Fig. 2 illustrate the variable relationship between area-based protection (actions) and our ability to deliver biodiversity outcomes across countries, as measured by the SPI. For example, increasing coverage in areas that only harbour species already sufficiently protected may not improve representation, whereas adding area that prioritizes inadequately conserved species leads to representation gains.

From measurement to decision support

In addition to offering measurement of the biodiversity outcomes of past decisions, the SPI can also directly aid future decision-making. Wherever objectives seek to extend area-based conservation in support of biodiversity outcomes, such direct measures should be integrated into spatial planning and prioritization efforts. Spatial decision-support tools, which algorithmically solve for different user-defined objectives, optimize network designs to produce the greatest benefits for species representation[18]. Scenarios developed from planning processes can be evaluated by comparing the different network configurations against sets of performance metrics linked directly to the GBF and national goals[18,22]. Doing so enables explicit trade-offs to be examined between the costs of area-based conservation and anticipated biodiversity outcomes, and ultimately improves transparency in decision-making[13,19].

Ensuring adequate biodiversity representation in spatial planning comes with its own sets of challenges and limitations. For example, it requires targets to be set for individual species, which commonly relies on 'rules of thumb' or complex population models rather than empirical insights on individual species' space needs[5]. For both EBVs and species target setting, data limitations are greater in megadiverse countries[20]. Further work also remains in the standardized measurement of the management effectiveness of conservation areas, but momentum is building for improved data that can then be used to adjust subsequent outcome estimates by weighting the respective contributions of individual conservation areas or management regimes.

A new generation of indicators

The SPI shares its science, technology and stewardship principles with the SHI, a headline indicator in the draft GBF that addresses Goal A milestones on the integrity of ecosystems and the health and genetic diversity of species population[11,23,24] (https://www.post-2020indicators.org). The SHI's measurement of change in area and connectivity of suitable habitats relative to a baseline builds on extensively used related approaches assessing conservation policies[11,25]. Both metrics connect local data — as published from national monitoring or citizen science (for example through GBIF, https://www.gbif.org) — to globally comparable indicator metrics via EBVs, and both support disaggregation to single species and kilometre-pixel planning units. Availability of suitable habitats is the key and broadly quantifiable determinant of population size, but other factors can affect local abundance and, where available, surveys can be used to refine this link. Detailed maps, links to underpinning data and transboundary context are provided through Map of Life (https://mol.org/indicators), and globally standardized national indicator values and metadata are available there or through GBF-associated dashboards. The EBV-based nature of the SPI and SHI and their empirical design following FAIR principles (findable, accessible, interoperable and reusable) enable transparency and substitution at any level from data to indicator and supports the independent use of national monitoring data and workflows. Countries can also leverage national information on species representation or habitat quality and use the same indicator methodology to independently generate SPI and SHI values using their own data or to address species of particular national interest (for example, as underway in Colombia, http://biomodelos.humboldt.org.co). Additional capacity support and training has the potential to strongly increase such bottom-up development and local co-ownership. These indicators are among a growing set, many of them developed in association with GEO BON (https://geobon.org/ebvs/indicators), that use new scientific data integration approaches to leverage novel data flows, such as from remote sensing and global data networks. Other examples include the Rate of Invasive Alien Species Spread Indicator[26] and the Biodiversity Habitat Index[27]. These types of products complement a previous generation of legacy indicators that are more qualitative (such as categorical species threat status or stand-alone high-value biodiversity areas) and by design less geographically representative, scalable and/or responsive to short-term change. By leveraging ongoing data flows, the new indicators can account for and provide planning support in concert with dynamic processes such as species range shifts from climate and land-use change. The necessarily quantitative and global nature of these indicators can represent impediments for bottom-up development and local co-ownership without capacity support. In our view, these challenges are not insurmountable given the value these indicators bring to better understanding how our conservation actions and interventions impact biodiversity. For the SPI and SHI, some challenges are helpfully addressed through the transparent use of species as base units, the potential for fully independent national calculation (for example, using national species information and/or land cover products), and the long-term data, measurement and usage support provided through GBIF, Map of Life and GEO BON.

Focused on outcomes

As nations develop their conservation strategies around the post-2020 GBF, they will be carefully balancing strict protection of biodiversity with the desires of a diverse range of stakeholders, including local communities, Indigenous peoples, NGOs and industries. Trade-offs will need to be considered for biodiversity conservation alongside other objectives such as carbon, food security, ecosystem services, justice and economic growth[13,15,19]. Similarly, compromises will need to be made as the world defines a shared global vision through the GBF goals, targets and indicators. As countries finalize the framework, we argue that biodiversity outcomes captured through adequate representation must be at the centre of area-based conservation strategies. To achieve this, we urge that the SPI should be added as a headline indicator, next to the headline indicator "Coverage of protected areas and OECMS (by effectiveness)" in the existing draft GBF. With species population EBVs benefitting from rapidly growing data at local to global sales, including from environmental sensor and citizen science data, animal tracking and traditional ecological knowledge, indicators such as the SPI and SHI are poised to further grow in relevance and rigor in the coming years. Critically, these measurements offer a direct pathway for capturing the differentiated responsibilities and ways to advance national goals and global contributions, by complementing in-country efforts with engagement in partner countries who share stewardship responsibilities[15,28]. ❐

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References

1. Report of the Open-Ended Working Group on the Post-2020 *Global Biodiversity Framework on its Third Meeting (Part I)* CBD/WG2020/3/5 (CBD, 2021).
2. Maxwell, S. L. et al. *Nature* **586**, 217–227 (2020).
3. *Protected Planet Live Report 2021* (UNEP-WCMC, IUCN, NGS, 2021).
4. Díaz, S. et al. *Science* **366**, eaax3100 (2019).
5. Visconti, P. et al. *Science* **364**, 239–241 (2019).
6. Maron, M. et al. *Conserv. Lett.* **14**, e12816 (2021).
7. Pressey, R. L. et al. *Trends Ecol. Evol.* **36**, 808–821 (2021).
8. Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Service (IPBES Secretariat, 2019).
9. *Living Planet Report 2020* (WWF, 2020).
10. Jetz, W. et al. *Nat. Ecol. Evol.* **3**, 539–551 (2019).
11. Powers, R. P. & Jetz, W. *Nat. Clim. Change* **9**, 323–329 (2019).
12. Wilson, E. O. *Half-Earth: Our Planet's Fight for Life* (WW Norton & Company, 2016).
13. Sala, E. et al. *Nature* **592**, 397–402 (2021).
14. Rinnan, D. S., Sica, Y., Ranipeta, A., Wilshire, J. & Jetz, W. Preprint at *bioRxiv* https://doi.org/10.1101/2020.02.05.936047 (2020).
15. Beger, M. et al. *Nat. Commun.* **6**, 8208 (2015).
16. Armstrong, C. *Conserv. Biol.* **33**, 554–560 (2019).
17. *Post-2020 Global Biodiversity Framework: Scientific and Technical Information to Support the Review of the Updated Goals and Targets, and Related Indicators and Baselines* CBD/SBSTTA/24/3 (CBD, 2020).
18. Moilanen, A., Wilson, K. A. & Possingham, H. *Spatial Conservation Prioritization: Quantitative Methods and Computational Tools* (Oxford Univ. Press, 2009).
19. Jung, M. et al. *Nat. Ecol. Evol.* **5**, 1499–1509 (2021).
20. Navarro, L. M. et al. *Curr. Opin. Environ. Sustain.* **29**, 158–169 (2017).
21. Jantke, K., Kuempel, C. D., McGowan, J., Chauvenet, A. L. M. & Possingham, H. P. *Divers. Distrib.* **25**, 170–175 (2019).
22. Bhola, N. et al. *Conserv. Biol.* **35**, 168–178 (2021).
23. Hansen, A. J. et al. *Conserv. Lett.* **14**, e12822 (2021).
24. *Measuring Ecosystem Integrity (Goal A) in the Post-2020 Global Biodiversity Framework: The Geo Bon Species Habitat Index* CBD/WG2020/3/INF/6 (CBD Secretariat, 2021).
25. Rondinini, C. & Visconti, P. *Conserv. Biol.* **29**, 1028–1036 (2015).
26. McGeoch, M. A. et al. Preprint at *bioRxiv* https://doi.org/10.1101/2021.08.26.457851 (2021).
27. Hoskins, A. J. et al. *Environ. Model. Softw.* **132**, 104806 (2020).
28. Adams, V. M., Visconti, P., Graham, V. & Possingham, H. P. *One Earth* **4**, 901–906 (2021).
29. Heiner, M. et al. *Conserv. Sci. Pract.* **1**, e110 (2019).

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Competing interests

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Additional information

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