To Inform Discussions at CBD/CoP-16

The Need for Disaggregated Indicators for Ecological Connectivity in the KMGBF Monitoring Framework

Main message

As part of discussions under CBD/CoP-16 Agenda Item 10 concerning "Mechanisms for planning, monitoring, reporting and review", this document recommends approaches to disaggregate the headline indicators of the KMGBF monitoring framework to better measure and report on connectivity. It is recommended that:

1) The current headline indicator "A.2 Extent of natural ecosystems" also be disaggregated: "**By level of connectivity"**; and

2) The current headline indicator "3.1 Coverage of protected areas and other effective area-based conservation measures" be disaggregated: **"By level of connectivity".**

Introduction

Ecological connectivity is the unimpeded movement of species, connection of habitats without hindrance and the flow of natural processes that sustain life on Earth.[1, 2] The Convention on Biological Diversity (CBD) Kunming-Montreal Global Biodiversity Framework (KMGBF) emphasizes the fundamental contribution that ecological connectivity makes to healthy functioning ecosystems and species, and its benefit to people, by including connectivity in a number of goals and targets to be advanced globally by Parties.[3]

The monitoring framework for the KMGBF[4] includes numerous indicators with relevance for ecological connectivity,[5] yet there are no headline indicators which adequately represent the connectivity element. In May 2024, the Subsidiary Body on Scientific, Technical and Technological Advice, at its 26th meeting (SBSTTA-26) noted[6] the gap analysis prepared by the Ad Hoc Technical Expert Group on Indicators (AHTEG) regarding "research needs and

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[1] Convention on Migratory Species Resolution 14.16 on Ecological Connectivity. https://www.cms.int/sites/default/files/document/cms_cop14_res.14.16_ecological-connectivity_e.pdf.

[2] Connectivity (Ecosystem) has been defined during discussions on the GBF glossary (https://www.cbd.int/doc/c/e2dd/6b6c/eaa4784e9111c58d6fd787ae/wg2020-04-02-en.pdf; https://www.cbd.int/doc/c/c874/6eb7/813f0201cd67299c9eb10a4a/wg2020-04-inf-02-rev-02-en.pdf), in reference to UNEP/CMS/Resolution 12.26 (Rev.COP13), as "Connectivity (i.e., ecological connectivity) is the unimpeded movement of species and the flow of natural processes that sustain life on Earth. It may thus also refer to continuous ecosystems often connected through ecological corridors. There are two types of connectivity: structural (in which the continuity between ecosystems is identified) and functional (in which the movement of species or processes is verified)."

[3] https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf; https://conservationcorridor.org/wp-content/uploads/Brief_Results-of-Ecological-Connectivity-in-Post2020-GBF.pdf.

[4] https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-05-en.pdf.

[5] https://conservationcorridor.org/wp-content/uploads/Version-1-Practical-Guidance-on-Indicators-of-Connectivity.pdf.

[6] https://www.cbd.int/doc/recommendations/sbstta-26/sbstta-26-rec-01-en.pdf, Annex III.

indicator development required for improved monitoring of the Kunming-Montreal Global Biodiversity Framework"[7] which includes the following passages (emphasis added):

> ***Goal A*** *is well covered overall by the headline indicators of the Framework. Only one major gap was identified: data on the abundance of native wild species. However, other aspects, such as extinction rate,* ***connectivity and integrity require additional steps to be accurately represented by the headline indicator****.*
>
> ***Two major gaps were identified for Target 3****: the coverage of areas of particular importance for ecosystem functions and services by protected areas and other effective area-based conservation measures and* ***the connectivity of these areas****.*

Considering the important need to fill these key remaining gaps, we urge Parties at the 16th Conference of the Parties to CBD (CBD/CoP-16), as part of discussions under Agenda Item 10 concerning "Mechanisms for planning, monitoring, reporting and review",[8] to consider the following recommendations and insights.

Disaggregation of Goal A headline indicator

Goal A reads: "The integrity, connectivity and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050".

We agree with the AHTEG that certain aspects, in particular accounting for ecosystem connectivity, could be improved to achieve Goal A for terrestrial, inland water, and coastal and marine areas.

Therefore, to increase focus and application of dedicated connectivity indicators for terrestrial, inland water, and coastal and marine areas, it is recommended that the current headline indicator "A.2 Extent of natural ecosystems" also be disaggregated as follows: "**By level of connectivity".**

How to disaggregate the headline indicator A.2 "By level of connectivity"

There are existing global indices that already provide a measure of the connectivity of ecosystems. These include component and complementary indicators from the monitoring framework, such as Ecoregional Intactness Index[9] and Ecosystem Integrity Index.[10] For ***inland water areas***, methodology and assessment would be based on the complementary indicator Connectivity Status Index,[11] which has been applied globally and at smaller scales.

If additional calculation of connectivity is desired at national level, this can be done for ***terrestrial areas*** by applying the following three steps:

1. "Natural" lands need to be identified, which is operationalized as identifying, on a per-pixel basis, the degree of human modification across the full gradient of landscape settings. Natural lands can be readily identified

[7] https://www.cbd.int/doc/c/d140/f363/5a2af2b9b67c9e69b645fb84/sbstta-26-02-en.pdf, Annex 3.
[8] https://www.cbd.int/doc/c/cfaf/1f29/4b7de3fe389bbd7edf629863/cop-16-01-add1-en.pdf.
[9] Beyer, Hawthorne, Venter, Oscar, Grantham, Hedley, and Watson, James(2019). Global assessment of ecoregion intactness. The University of Queensland. Data Collection. https://doi.org/10.14264/uql.2019.773.
[10] Hill, S.L.L, Harrison, M.L.K, Maney, C., Fajardo, J., Harris, M., Ash, N., Bedford, F.S., Danks, D., Guaras, J., Hughes, J., Jones, M., Mason, T., Burgess, N (preprint). The Ecosystem Integrity Index. bioRxiv, 2022.08.21.504707. https://doi.org/10.1101/2022.08.21.504707.
[11] Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., ... & Zarfl, C. (2019). Mapping the world's free-flowing rivers. Nature, 569(7755), 215-221. https://doi.org/10.1038/s41586-019-1111-9.

using the human modification framework, a well-known, fit-for-purpose approach, with readily available globally consistent, comprehensive, and detailed (90-300 m) datasets.[12, 13]

2. The degree to which ecosystems are *permeable* to the flow of species and ecological processes across a landscape is calculated by assigning, for each pixel, a value of 1 where the natural value is greater than a random value, and then identifying clusters of "patches" formed by contiguous pixels of value=1.[14]
3. This is run multiple times (e.g., ≥30) and the mean area of the clusters is assigned to each pixel, normalized by the maximum possible cluster size, resulting in a 0-1.0 metric of permeability.

Permeable (or connected) landscapes allow for critical ecological functioning such as genetic diversity and the potential for species to adapt to climate and land use change.[15, 16] Landscape permeability can be readily calculated over time and at global to country to local extents using basic GIS software and minimal computational resources. Because multiple conservation actions typically are needed that range from protection to restoration, this approach built on representing the gradient of human modification can be readily applied also to semi-natural ecosystems as they retain substantial biodiversity and are thus important to protect from a biodiversity perspective, while intensively modified ecosystems have substantial anthropogenic impacts on biodiversity (CBD guidance).

Disaggregation of Target 3 headline indicators

Target 3 reads "*Ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative**, well-connected** and equitably governed systems of protected areas and other effective area-based conservation measures, recognizing indigenous and traditional territories where applicable, and integrated into wider landscapes, seascapes and the ocean, while ensuring that any sustainable use, where appropriate in such areas, is fully consistent with conservation outcomes, recognizing and respecting the rights of indigenous peoples and local communities, including over their traditional territories.*

As currently written, the headline indicator for Target 3 is "3.1 Coverage of protected areas and other effective area-based conservation measures." We agree with the AHTEG that this current formulation could be improved to better address the "well-connected" element of the Target.

To reveal information on connectivity of a country's set of protected areas and other effective area-based conservation measures, it is recommended that current headline indicator "3.1 Coverage of protected areas and other effective area-based conservation measures" be disaggregated as follows: **"By level of connectivity".**

[12] Kennedy, C. M., Oakleaf, J. R., Theobald, D. M., Baruch-Mordo, S., & Kiesecker, J. (2019). Managing the middle: A shift in conservation priorities based on the global human modification gradient. *Global change biology*, *25*(3), 811-826.

[13] Theobald, D.M., Kennedy, C., Chen, B., Oakleaf, J., Baruch-Mordo, S. and Kiesecker, J., 2020. Earth transformed: detailed mapping of global human modification from 1990 to 2017. Earth System Science Data, 12(3), pp.1953-1972.

[14] Gardner, R.H., Milne, B.T., Turnei, M.G. and O'Neill, R.V., 1987. Neutral models for the analysis of broad-scale landscape pattern. *Landscape ecology*, *1*, pp.19-28.

[15] Hilty, J., Worboys, G. L., Keeley, A., Woodley, S., Lausche, B. J., Locke, H., ... & Tabor, G. M. (2020). Guidelines for conserving connectivity through ecological networks and corridors.

[16] Riva, F. and Fahrig, L., 2023. Landscape-scale habitat fragmentation is positively related to biodiversity, despite patch-scale ecosystem decay. *Ecology Letters*, *26*(2), pp.268-277.

This disaggregation reveals information on the connectivity of protected areas and other effective area-based conservation measures, and therefore their effectiveness to conserve biodiversity.

How to disaggregate the headline indicator 3.1 "By level of connectivity"

There are existing global indices that already provide a measure of the connectivity of protected areas (PAs) and other effective area-based conservation measures (OECMs). These include component and complementary indicators from the monitoring framework, such as Protected Area Isolation (PAI),[17] Protected and Connected (ProtConn),[18] Protected Networks (ProNet),[19] or Intact Wilderness (ConnIntact)[20] that can be used for this disaggregation.

If additional calculation of connectivity is desired at national level, this can be done by summing the area of PAs and OECMs that are connected to other PAs and OECMs.

Two PAs and/or OECMs can be considered structurally connected (a) if they are relatively close together (e.g., 30km apart);[21] or (b) if human modification of the area in between the PAs and/or OECMs is relatively low.[22, 23] Option (a) is called 'Euclidean distance'; Option (b) is called 'ecological distance'. While it is easier to decide whether two PAs and/or OECMs are connected using the Euclidean distance, the ecological distance will often be a better reflection of reality, because human activities such as developed areas and roads can present a barrier to wildlife movement. If the level of human activities is low, wildlife can move from one PA and/or OECM to another, meaning that they are connected. A third option (c) could be to reflect functional connectivity by using data on a species or a set of species to decide whether two PAs and/or OECMs are connected.[24] Countries can select the option that best matches their capacities and interests. The related steps to calculate the disaggregated connectivity indicator are:

1. Decide which PAs and/or OECMs to include, ideally a country's entire network;
2. Select method and available dataset for calculating distances between PAs and/or OECMs (Euclidean distance, ecological distance, or species-informed distances);
3. Select thresholds below which two PAs and/or OECMs are considered connected (default recommendation for Euclidean distance is 30km, but can range from 10-300km);
4. Decide how many PAs and/or OECMs, and/or combined areas are required in each cluster for it to be included; and
5. Calculate the area of PAs and/or OECMs included in the retained clusters.

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[17] Brennan, A., Naidoo, R., Greenstreet, L., Mehrabi, Z., Ramankutty, N., & Kremen, C. (2022). Functional connectivity of the world's protected areas. Science, 376(6597), 1101-1104. https://doi.org/10.1126/science.abl8974.

[18] Saura, S., Bastin, L., Battistella, L., Mandrici, A., & Dubois, G. (2017). Protected areas in the world's ecoregions: How well connected are they?. Ecological indicators, 76, 144-158. https://doi.org/10.1016/j.ecolind.2016.12.047.

[19] Theobald, D. M., Keeley, A. T., Laur, A., & Tabor, G. (2022). A simple and practical measure of the connectivity of protected area networks: The ProNet metric. Conservation Science and Practice, 4(11), e12823. https://doi.org/10.1111/csp2.12823.

[20] Ward, M., Saura, S., Williams, B., Ramírez-Delgado, J. P., Arafeh-Dalmau, N., Allan, J. R., ... & Watson, J. E. (2020). Just ten percent of the global terrestrial protected area network is structurally connected via intact land. Nature communications, 11(1), 4563. https://doi.org/10.1038/s41467-020-18457-x.

[21] Saura, S., Bertzky, B., Bastin, L., Battistella, L., Mandrici, A., & Dubois, G. (2018). Protected area connectivity: Shortfalls in global targets and country-level priorities. *Biological conservation*, *219*, 53-67.

[22] Ward, M., Saura, S., Williams, B., Ramírez-Delgado, J. P., Arafeh-Dalmau, N., Allan, J. R., ... & Watson, J. E. (2020). Just ten percent of the global terrestrial protected area network is structurally connected via intact land. *Nature communications*, *11*(1), 4563.

[23] Theobald, D.M., Kennedy, C., Chen, B., Oakleaf, J., Baruch-Mordo, S. and Kiesecker, J., 2020. Earth transformed: detailed mapping of global human modification from 1990 to 2017. *Earth System Science Data*, *12*(3), pp.1953-1972.

[24] Joshi, A., Vaidyanathan, S., Mondol, S., Edgaonkar, A., & Ramakrishnan, U. (2013). Connectivity of tiger (Panthera tigris) populations in the human-influenced forest mosaic of central India. PloS one, 8(11), e77980.