Manuscript title: Biodiversity indicators miss local and short-term change: A blank space waiting to be filled

Author names: Katherine Hébert[1], Maximiliane Jousse[1], Janaína Serrano[1], Dirk Nikolaus Karger[2], F. Guillaume Blanchet[3,4,5], Laura J. Pollock[1].

Author affiliations:

[1] Department of Biology, McGill University, Québec, Canada.

[2] Swiss Federal Research Institute WSL, 8903, Birmensdorf, Switzerland

[3] Département de biologie, Université de Sherbrooke, Québec, Canada

[4] Département de mathématiques, Université de Sherbrooke, Québec, Canada

[5] Département des sciences de la santé communautaire, Université de Sherbrooke, Québec, Canada

Corresponding author: Katherine Hébert (katherine.hebert@mcgill.ca)

Keywords: Indicators, Global Biodiversity Framework, gap analysis, spatiotemporal scales, monitoring, decision support, conservation.

Abstract

The year 2030 is rapidly approaching. Building, monitoring, and reporting indicators to evaluate the 2030 targets in the Kunming-Montreal Global Biodiversity Framework (GBF) is a major challenge that requires, at minimum, nations to assess their progress at least once within the next five years. To effectively capture this progress, we need indicators that capture fast-paced, on-the-ground biodiversity change, alongside slower, more diffuse biodiversity trends at national scales. We gathered a group of biodiversity scientists and practitioners to evaluate how well common types of indicators cover the space-time continuum of biodiversity changes. We highlight a striking, nearly unanimously agreed upon, gap in the available indicator toolbox in our ability to capture on-the-ground biodiversity changes. To fill this blank space, we call for investment in local-scale and short-term monitoring, research on how to optimize this monitoring for rapid detection, and urgent development of indicators at these more actionable scales.

Introduction

Biodiversity indicators characterize the state of biodiversity through time, typically measured with Essential Biodiversity Variables (EBV, Pereira et al., 2013), to draw inferences about changes in that state (Jones et al., 2011). Ideally, a biodiversity indicator summarizes complex data into a meaningful value that can be interpreted to inform policy, management, and conservation actions. In short, indicators are essential to monitor progress towards global biodiversity targets.

Summarizing biodiversity change with indicators represents an enormous challenge: an indicator must simplify the variability of biodiversity change into a value that can be used to make decision, while retaining enough information to provide a reliable portrait of the state of biodiversity (Jones et al., 2011). In addition to the challenge of developing a simple metric without sacrificing reliability, detecting signals of biodiversity change from uncertain data is a major challenge (Johnson et al., 2024; Leung & Gonzalez, 2024), which is particularly difficult at local scales (Valdez et al., 2023). Because no single indicator can capture the many dimensions (from gene to ecosystem) and scales (from local to landscape) of biodiversity (Noss, 1990; Bundy, Gomez, & Cook, 2019), it is essential to rely on a suite of indicators with complementary abilities to detect changes.

It is particularly important to report indicators at scales that are relevant for decision-making (Piipponen-Doyle et al., 2021). In the context of the Kunming-Montreal Global Biodiversity Framework, this means that we need indicators that can evaluate the targets that are set for 2030 as well as longer-term goals for 2050 (CBD, 2022a). To be effective, indicators should be reported frequently enough to proactively detect biodiversity changes while actions are still feasible (Schmeller et al., 2018). To meet the 2030 deadline, biodiversity targets must be evaluated at least once within the next five years, though progress should be reported much earlier to proactively implement and adjust national biodiversity strategies. On this tight schedule, much of the progress towards national targets will be made at local scales (such as municipalities, or parks), where the effects of conservation action and decision-making are most immediate. Though national-scale indicators are essential to summarise progress towards targets, they are too zoomed out to reflect the local changes that set the course of biodiversity trends in the short term. As such, the suite of indicators that measure progress towards the 2030 targets must be carefully assembled to capture a range of spatiotemporal scales of biodiversity change.

Despite the rapid proliferation of indicators, we lack an overall picture of how well-suited our leading indicators work together to monitor biodiversity changes across space and time. To evaluate how well indicators cover the space-time continuum of biodiversity changes, in the "Tracking a Moving Target" workshop at the 2023 GeoBON: Monitoring for Biodiversity conference, we asked 78 participants to delineate how well-equipped we are to monitor short-term (< 5 years) to long-term (50+ years) biodiversity changes, from local (e.g., municipalities and parks) to national scales with a selection of indicators (Table 1). The workshop participants were experts, decision-makers, and practitioners in biodiversity science, monitoring, and the development and assessment of biodiversity indicators. The consensus reveals a gap in our ability to track short-term local changes with the current indicator toolbox. To meet the fast-approaching 2030 targets, we call for focused monitoring and indicator development at local and short-term scales, to ensure that we can monitor biodiversity change at actionable scales.

Building a portrait of indicator sensitivity across space and time

The "Tracking a Moving Target" workshop at the GeoBON: Monitoring for Biodiversity conference in Montreal, Canada in October 2023 gathered biodiversity scientists and practitioners to discuss the sensitivity of our current indicator toolbox across a range of temporal and spatial scales. The objective of the workshop was to build a first portrait of how well common types of indicators cover the range of spatiotemporal scales that are relevant for monitoring and decision support. The workshop spanned two sessions (Session 1 = 90 minutes, Session 2 = 120 minutes), during which a total of 78 participants self-organised into 12 groups of 5 to 10 people.

Each group was given a list of six indicators of species-level and ecosystem-level biodiversity trends (Table 1) adopted in the Kunming-Montreal Global Biodiversity Framework with the goal to define the efficiency of each indicator in capturing local to national scale change across a short to long time period. Importantly, this exercise assumed that data is unlimited and unbiased to focus discussions on indicator properties rather than the limits of available data. Participants delineated the suitability of the six indicators on a categorical space-time grid. The spatial axis covered different scales at which conservation action, decision-making, and policies are applied, ranging from local scales (municipalities and parks) to regional scales (counties, ecoregions), subnational scales (provinces, states), and national scales (countries). The time axis covered different periods to evaluate progress within the GBF, ranging from short-term evaluation of the 2030 targets (0-2, 2-4, 4-6 years), to post-2030 assessments for the 2050 goals (6-10, 10-20 years), to long-term reporting beyond 2050 (20-50, and 50+ years). For each indicator, each group outlined an area on the space-time grid where they determined the indicator to be useful for decision support and/or monitoring of biodiversity changes (Fig. 1). This outline was drawn as a solid line if participants considered their delineation to be certain, and as a dotted line if it was uncertain.

Each group was also asked to consider one of three scenarios of biodiversity change (Table S1; early signs of decline, improving ecosystem health, increasing uncertainty from changing disturbance regimes) and one of two use cases (monitoring, or decision-support), to determine whether we are better equipped to measure biodiversity change in specific contexts (Supplementary material S1). However, the consensus among groups (Fig. 2) did not strongly differ by scenario (Fig. S1) or by use case (Fig. S2) when these were reported.

To visualise the coverage of indicators on the space-time continuum, we digitized each space-time grid and overlaid a grid on each one that matched the axis labels drawn by each group. We counted grid cells that were at least 50% occupied by an indicator's boundaries, and noted whether the grid cells were marked as certain or uncertain. To describe the coverage of the indicator suite, we took the z-score of counts per cell across all indicators. To illustrate each indicator's suitability, we set a box bound by the 25% and 75% quantiles of grid cell counts on the time and the space axis. These portraits represent the confidence that participants had in the suitability of the indicators to monitor biodiversity changes across spatiotemporal scales and should not be interpreted as a quantitative assessment of indicator sensitivity.

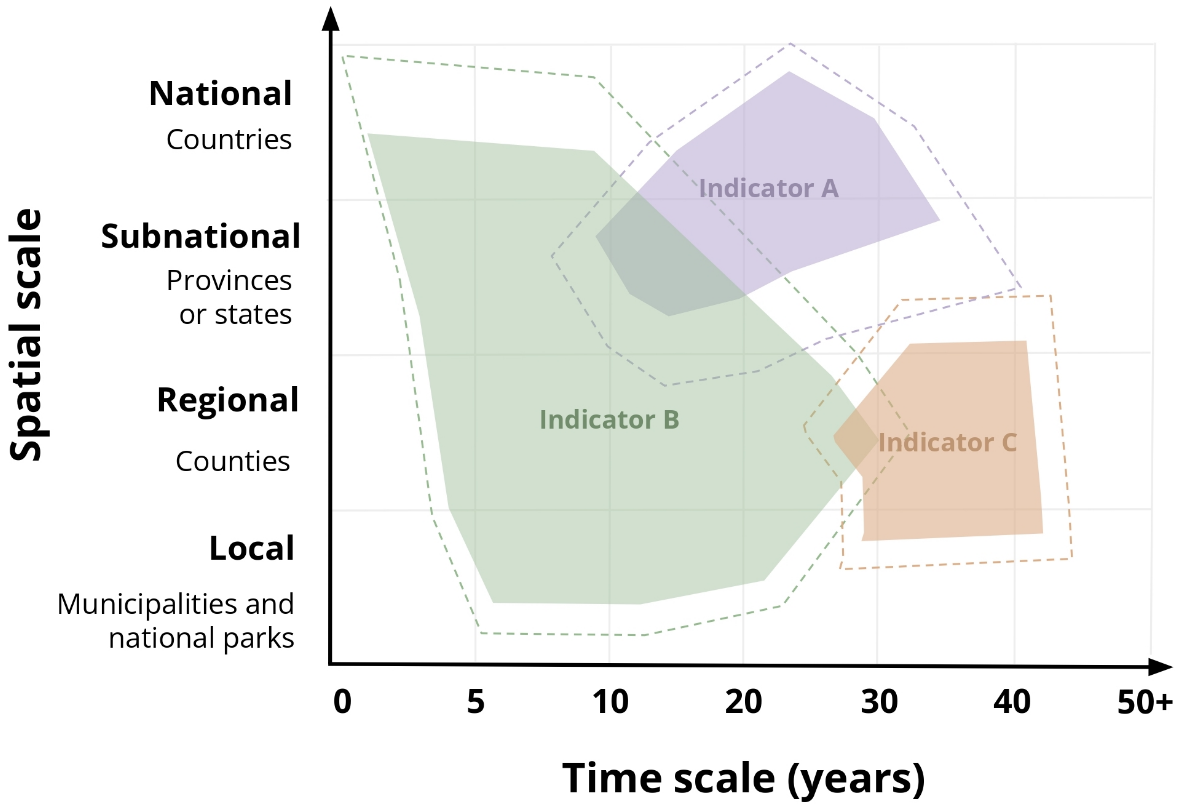

Figure 1. Example of a space-time grid showing the suitability of three indicators on a space-time gradient for decision support and monitoring of biodiversity changes. Certain (solid line) and uncertain (dashed line) boundaries are drawn for three example indicators (A, B, C).

Table 1: The suite of indicators to be placed on space-time grids during the "Tracking a Moving Target" workshop at the GeoBON: Monitoring for Biodiversity conference.

Indicator	**GBF Category**	**Type**	**What it measures**	**Reference**
Red List Index	Headline	Species	Average trend in the extinction risk status of species assessed by the IUCN Red List.	(Butchart et al., 2005)
Living Planet Index	Component	Species	Change in vertebrate population size relative to 1970.	(Collen et al., 2009)
Ne > 500	Headline	Species	Proportion of populations within species with an effective population size > 500.	(Hoban et al., 2020)
Species Protection Index	Component	Species	Biodiversity representativeness of terrestrial protected areas.	(Jetz et al., 2022)
Red List of Ecosystems	Headline	Ecosystem	Risk of collapse status of ecosystems.	(Nicholson et al., 2024)
Extent of natural ecosystems	Headline	Ecosystem	Area of natural ecosystems defined based on IUCN GET biomes.	(UN-WCMC, 2023)

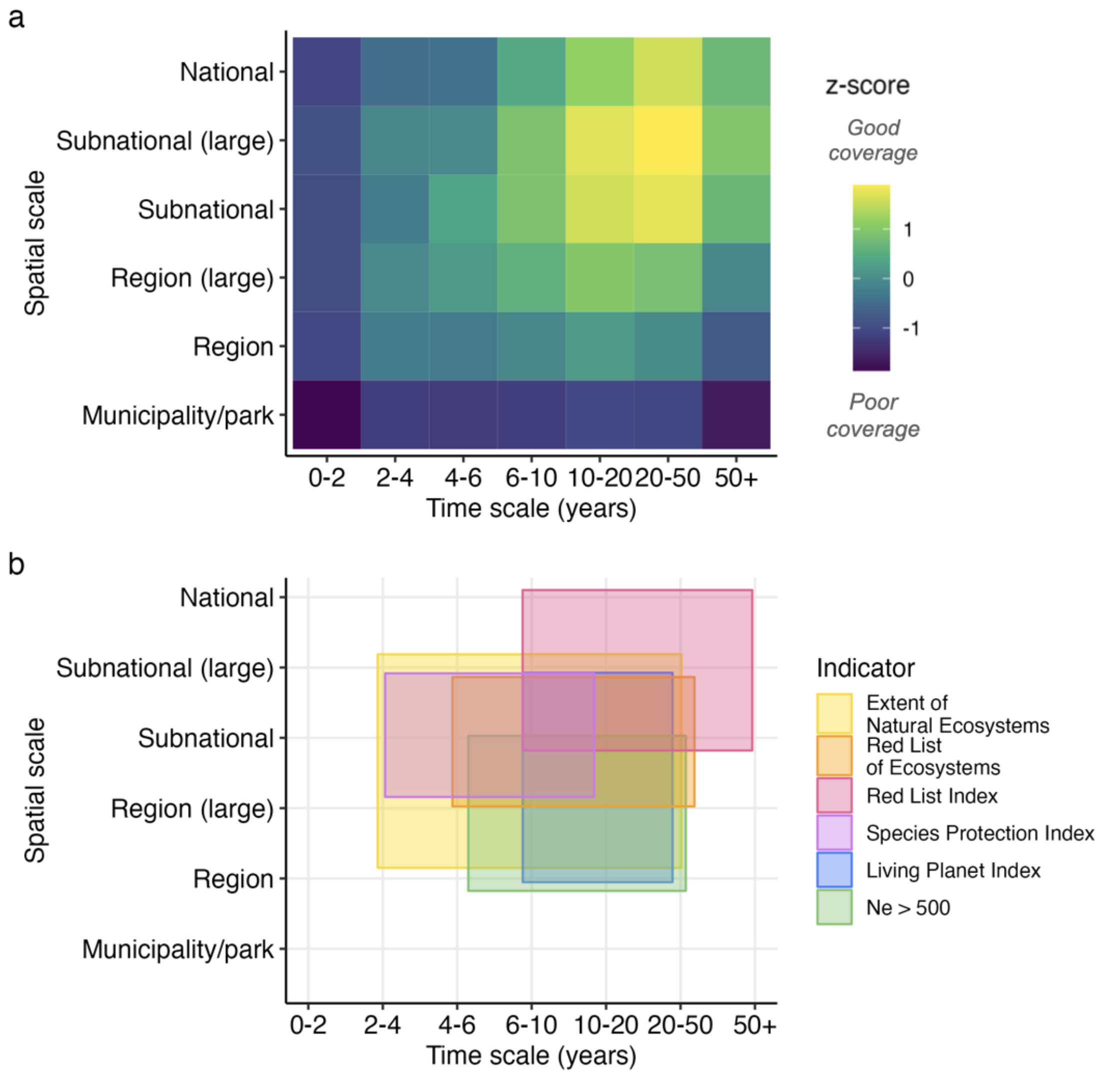

Figure 2. Consensus from the 24 grids drawn by 12 groups of workshop participants, showing the coverage of the indicator suite to support decisions and monitor biodiversity change from local to national scales, and from short-term (0-6 years) to long-term (50+ years) scales. (a) Z-scores of the counts of groups' delineations for all indicators on the space-time grid, weighted by certainty level, where the weight of uncertain boundaries is halved. (b) Each indicator's coverage of biodiversity changes across temporal and spatial scales. Each box delineates the 25% and 75% quantiles of the grid cell counts that describe each indicator's suitability as drawn by the workshop participants. The boundaries are lightly jittered to show overlapping boxes.

We lack indicators at actionable time scales

To successfully meet the Global Biodiversity Framework's targets, we need indicators that can detect changes in the state of biodiversity within politically-relevant timeframes (Piipponen-Doyle, Bolam, & Mair, 2021). However, biodiversity experts and practitioners do not feel they have indicators in their toolbox that can capture changes within the short timeframe (< 6 years) that is needed to evaluate progress towards biodiversity targets by 2030, and this applies across all spatial scales (Fig. 2a). Given that biodiversity does not respond immediately to conservation action (Watts et al., 2020), we are likely overestimating our current ability to detect progress towards the 2030 global targets in six years. In other words, the current indicators will not be used to guide or validate the decisions or conservation actions that are needed to make progress towards the 2030 targets.

Indicators that are sensitive to actions, rather than to biodiversity change itself, may prove most helpful to gauge short-term (< 6 years) progress towards global targets. For example, decision-oriented indicators like the Species Protection Index (SPI) reflect the creation of conserved or protected areas and may change immediately in response to conservation action, though they will not respond directly to biodiversity change. This short-term sensitivity to action is in contrast to ecosystem-oriented or species-oriented indicators which may require several years to disentangle trends from random variability (Stevenson et al., 2021), but which directly measure the state of biodiversity. However, even indicators that can be compiled annually like the Living Planet Index or the Wild Bird Index may only reflect species' responses to conservation action after a time lag (Watts et al., 2020), or may not have the power required to detect them at all (Leung & Gonzalez, 2024). To effectively capture progress towards global targets, the suite of reported indicators must therefore assemble metrics that have complementary sensitivity to different temporal signatures of the outcomes of conservation action (i.e., some indicators that directly reflect action, while others measure the outcomes of these actions on biodiversity).

Progress towards global targets must be measured at the scale of conservation

The workshop uncovered a consensus that we lack confidence in our capacity to evaluate progress at local scales with the current indicator toolbox (Fig. 2a). Participants were, in fact, very certain that there is a lack of suitable indicators to measures changes at the municipality or park scales, particularly over longer time periods (50+ years) (Fig. 3). None of the proposed indicators were considered to be suitable for tracking local-scale trends by the workshop participants (Fig. 2b), though the Living Planet Index, Ne > 500, and the Extent of Natural Ecosystems may be suitable at regional scales. However, local conservation actions are at the core of our ability to prevent or reverse biodiversity loss, and their outcomes scale up to drive progress towards national and global biodiversity targets (Saterson et al., 2004; Shin et al., 2022). For this reason, the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES) has emphasized the importance of integrating local and regional knowledge in measurements of biodiversity loss, and in strategies to slow, prevent, and reduce this loss (IPBES, 2019).

Because biodiversity targets are set at international political scales, it can be difficult to maintain a clear link between local conservation actions and global, or even national, strategies to halt biodiversity loss (Perino et al., 2022). Framing biodiversity loss as a global issue is essential to set international conservation priorities, allocate resources for conservation, and support decision-making based on the most complete global knowledge (Chaplin-Kramer et al., 2022). However, local conservation actions are required to make progress towards national and global targets (Langhammer et al., 2024). As such, it is equally important to assess local trends in the state of biodiversity to measure progress at the scale of conservation action (Saterson et al. 2004). To integrate more fine-scale assessments of progress into the GBF monitoring framework, a monitoring strategy must be designed to capture local-scale changes in biodiversity but also the outcomes of local conservation actions (Leung & Gonzalez, 2024). Strengthening this link between global indicators and local actions must be a priority going forward (Nicholson et al., 2021).

A pressing need to assess indicator performance in scenarios of biodiversity change

Delineating the suitability of indicators on the space-time grids revealed that it is often difficult to know exactly where indicators work best in time and space. Given that this workshop was presented during the GeoBON: Monitoring for Biodiversity conference, most participants had some familiarity or direct experience with the development, use, and reporting of the indicators that were presented for discussion (Table 1). Even with some prior knowledge of the proposed indicators, the consensus reveals nearly unanimous uncertainty in the suitability of the indicator suite to monitor biodiversity changes at short time scales (< 6 years) across all geographic scales (Fig. 3). This highlights a gap in our ability to measure changes at the time scales that are needed to evaluate the 2030 targets in the Global Biodiversity Framework.

This uncertainty is due, in part, to a lack of assessments of indicator performance, which limits our ability to precisely identify the spatiotemporal scales at which each indicator performs well enough for monitoring and/or decision support. The urgent need to monitor biodiversity change means that indicators are often calculated and reported before their ability to detect expected changes has been tested. Some indicators have been tested more rigorously (Watermeyer et al., 2021; Vicente et al., 2022), including the Living Planet Index (McRae, Deinet, & Freeman, 2017; Leung et al., 2020; Buschke, Hagan, Santini, & Coetzee, 2021; Hébert & Gravel, 2023; Leung & Gonzalez, 2024), which helped to clarify the limits of their accuracy and uncertainty and thus how to use them. However, such a thorough assessment is exceptional, and most indicators are selected to evaluate future targets even if it is not yet clear if they can capture the targeted changes.

It must become standard practice to test the conditions under which indicators detect the changes they are intended to monitor (Nicholson et al., 2021), especially at the spatiotemporal scales that are required for decision support and monitoring. Biodiversity indicators summarise large volumes of noisy information into a simplified metric, which is a calculation that can accumulate uncertainty and distort studied trends (Hébert & Gravel, 2023). Evaluating the impact of this uncertainty on our ability to detect changes is essential (Johnson et al., 2024), and each indicator must be interpreted carefully while considering the bounds of its reliability, according to the level of certainty we require to make decisions (Leung & Gonzalez, 2024). The accuracy and uncertainty of indicators must be evaluated under scenarios of biodiversity change (e.g., Table S1) to establish how confidently they should be interpreted as metrics of biodiversity change in space and time.

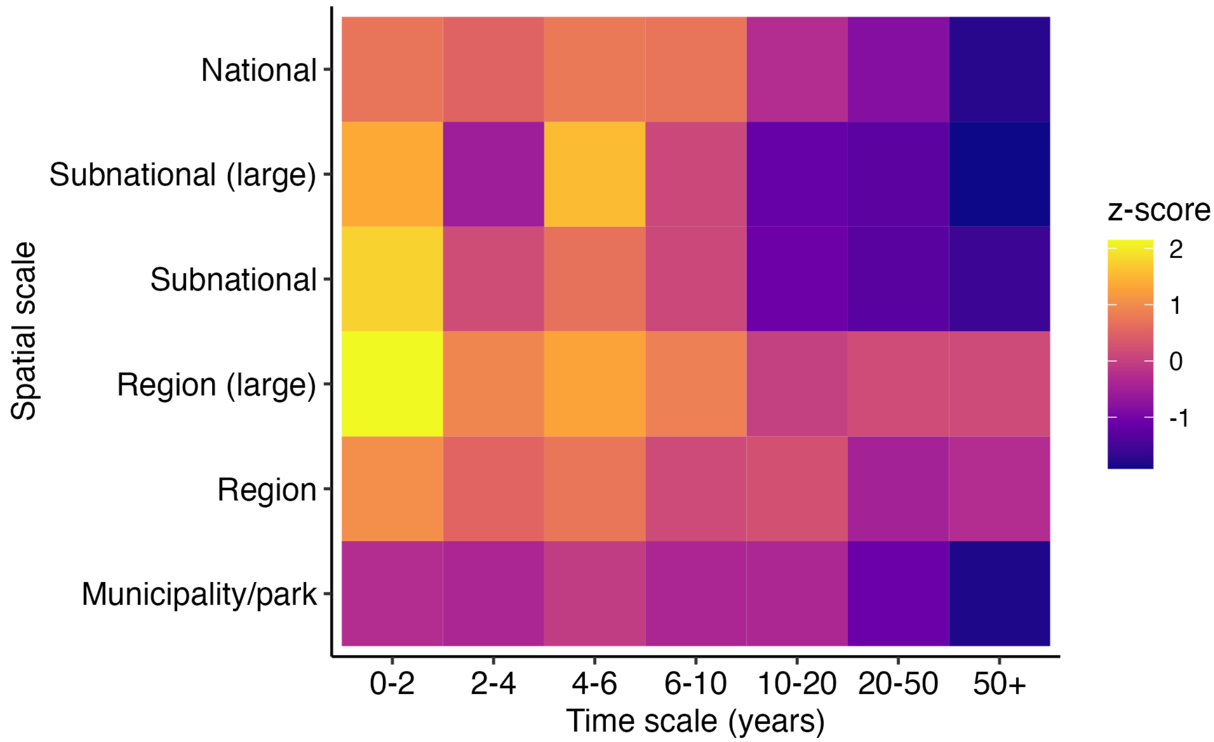

Figure 3. Uncertainty in the indicators' applicability from local to national scales, and from short-term (0-6 years) to long-term (50+ years) scales. This uncertainty is a consensus from the 24 grids drawn by 12 groups of workshop participants. Uncertainty is shown as the z-scores of the counts of groups' delineations for all indicators on the space-time grid that were marked as uncertain, where a grid cell with a high z-score (yellow) shows that participants thought some indicators could be suitable for the given scale but were mostly uncertain, while a grid cell with a low z-score (purple) shows that participants were generally certain in the coverage or lack of coverage of the given scale.

A suite of indicators is more than the sum of its parts

Biodiversity change unfolds differently across scales (Chase et al., 2018), and it is important to monitor this change with a suite of indicators that can capture multiple dimensions of biodiversity (Perino et al., 2022; Vicente et al., 2022). Evaluating indicators as a set, rather than a collection of individual metrics, is key to assess the complementarity and redundancy in their combined capacity to capture biodiversity change across scales (Nicholson et al., 2021; Stevenson et al., 2024).

Identifying gaps and redundancies in the sensitivity of a suite of indicators is a critical first step to set priorities for monitoring and indicator development. For example, although only a handful of indicators (Table 1) were considered during the workshop, the consensus highlights redundancy among indicators that are well-suited to capture biodiversity changes at the mid- to long-term (10 to 50 years) and at regional to national scales (Fig. 2a). The existing redundancy in the coverage of long-term and large-scale biodiversity changes could be leveraged to cross-validate trends across similar indicators (Stevenson et al., 2024), to assess progress towards long-term goals with multiple datasets and metrics. However, rather than deepening these redundancies, the development of new indicators and monitoring schemes must urgently target the gaps in the indicator suite's coverage of biodiversity changes across space and time.

Conclusion: We need strategic monitoring and indicator development at more actionable scales

The development of indicators has been prolific to fulfill the urgent need to evaluate the global biodiversity targets set by the Convention on Biological Diversity. This burst in indicator development is reflected in the large catalogue of indicators that have been proposed in the

Kunming-Montreal Global Biodiversity Framework (CBD, 2022b). However, if indicators continue to be developed without considering their contribution to the pre-existing “toolbox” (Sparks et al., 2011), we risk investing time and resources in metrics that offer redundant information while missing critical dimensions of biodiversity change.

The blank space in the indicator suite at local and short-term scales means that we are lacking sensitivity to biodiversity change at actionable scales. First, the indicator suite is poorly equipped to detect changes before 2030, which means political and conservation actions cannot be proactively assessed to ensure that we are on track to successfully meet the 2030 targets in the Kunming-Montreal Global Biodiversity Framework. Second, the lack of sensitivity to smaller organisation scales (municipalities and parks) means that target progress cannot be evaluated or reported at the scale of critical conservation action and decision-making (Christie et al., 2020).

To ensure that progress towards global biodiversity targets can be reported by 2030, we must focus efforts on better integrating local and short-term biodiversity trends into our assessments of national biodiversity targets. The blank space in indicator suitability at actionable scales must be remedied through strategic monitoring and indicator development with the specific objective of tracking finer-scale evidence of progress towards global biodiversity targets.

Acknowledgements

This paper originated from the “Tracking a Moving Target: Testing and Benchmarking Indicators of Biodiversity Change” workshop during the GeoBon: Monitoring for Biodiversity conference in Montreal, Canada in October 2023. The authors thank Walter Jetz for commenting on the structure of the workshop, Brian Leung and Alice Hughes for their critical feedback, and Adriana Radulovici, Andrew Gonzalez and the GeoBON team for providing workshop support.

We are grateful to the 78 people who participated in the workshop, and whose discussions and engagement in the workshop inspired this paper.

References

Bundy, A., Gomez, C., & Cook, A. M. (2019). Scrupulous proxies: Defining and applying a rigorous framework for the selection and evaluation of a suite of ecological indicators. *Ecological Indicators*, *104*, 737–754.

Buschke, F. T., Hagan, J. G., Santini, L., & Coetzee, B. W. T. (2021). Random population fluctuations bias the Living Planet Index. *Nature Ecology & Evolution*, *5*, 1145–1152.

Butchart, S. H. M., Stattersfield, A. j, Baillie, J., Bennun, L. a, Stuart, S. n, Akçakaya, H. r, … Mace, G. m. (2005). Using Red List Indices to measure progress towards the 2010 target and beyond. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *360*, 255–268.

CBD. (2022a). *15/4. Kunming-Montreal Global Biodiversity Framework*.

CBD. (2022b). 15/5. Monitoring framework for the Kunming-Montreal Global Biodiversity Framework. *Conference of the Parties to the Convention on Biological Diversity*. Montreal, Canada.

Chaplin-Kramer, R., Brauman, K. A., Cavender-Bares, J., Díaz, S., Duarte, G. T., Enquist, B. J., … Zafra-Calvo, N. (2022). Conservation needs to integrate knowledge across scales. *Nature Ecology & Evolution*, *6*, 118–119.

Chase, J. M., McGill, B. J., McGlinn, D. J., May, F., Blowes, S. A., Xiao, X., … Gotelli, N. J. (2018). Embracing scale-dependence to achieve a deeper understanding of biodiversity and its change across communities. *Ecology Letters*, *21*, 1737–1751.

Christie, A. P., Amano, T., Martin, P. A., Petrovan, S. O., Shackelford, G. E., Simmons, B. I., … Sutherland, W. J. (2020). Poor availability of context-specific evidence hampers decision-making in conservation. *Biological Conservation*, *248*, 108666.

Collen, B., Loh, J., Whitmee, S., McRae, L., Amin, R., & Baillie, J. E. M. (2009). Monitoring change in vertebrate abundance: The Living Planet Index. *Conservation Biology*, *23*, 317–327.

Hébert, K., & Gravel, D. (2023). The Living Planet Index's ability to capture biodiversity change from uncertain data. *Ecology*, *104*, e4044.

Hoban, S., Bruford, M., D'Urban Jackson, J., Lopes-Fernandes, M., Heuertz, M., Hohenlohe, P. A., … Laikre, L. (2020). Genetic diversity targets and indicators in the CBD post-2020 Global Biodiversity Framework must be improved. *Biological Conservation*, *248*, 108654.

IPBES. (2019). *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (p. 1148). IPBES secretariat, Bonn, Germany.: IPBES.

Jetz, W., McGowan, J., Rinnan, D. S., Possingham, H. P., Visconti, P., O'Donnell, B., & Londoño-Murcia, M. C. (2022). Include biodiversity representation indicators in area-based conservation targets. *Nature Ecology & Evolution*, *6*, 123–126.

Johnson, T. F., Beckerman, A. P., Childs, D. Z., Webb, T. J., Evans, K. L., Griffiths, C. A., … Freckleton, R. P. (2024). Revealing uncertainty in the status of biodiversity change. *Nature*, 1–7.

Jones, J. P. G., Collen, B., Atkinson, G., Baxter, P. W. J., Bubb, P., Illian, J. B., … Milner-Gulland, E. J. (2011). The Why, What, and How of Global Biodiversity Indicators Beyond the 2010 Target. *Conservation Biology*, *25*, 450–457.

Langhammer, P. F., Bull, J. W., Bicknell, J. E., Oakley, J. L., Brown, M. H., Bruford, M. W., … Brooks, T. M. (2024). The positive impact of conservation action. *Science*, *384*, 453–458.

Leung, B., & Gonzalez, A. (2024). Global monitoring for biodiversity: Uncertainty, risk, and power analyses to support trend change detection. *Science Advances*, *10*, eadj1448.

Leung, B., Hargreaves, A. L., Greenberg, D. A., McGill, B., Dornelas, M., & Freeman, R. (2020). Clustered versus catastrophic global vertebrate declines. *Nature*, *588*, 267–271.

McRae, L., Deinet, S., & Freeman, R. (2017). The diversity-weighted living planet index: Controlling for taxonomic bias in a global biodiversity indicator. *PLoS ONE*, *12*, e0169156.

Nicholson, E., Andrade, A., Brooks, T. M., Driver, A., Ferrer-Paris, J. R., Grantham, H., … Obura, D. (2024). Roles of the Red List of Ecosystems in the Kunming-Montreal Global Biodiversity Framework. *Nature Ecology & Evolution*, 1–8.

Nicholson, E., Watermeyer, K. E., Rowland, J. A., Sato, C. F., Stevenson, S. L., Andrade, A., … Watson, J. E. M. (2021). Scientific foundations for an ecosystem goal, milestones and indicators for the post-2020 global biodiversity framework. *Nature Ecology & Evolution*, *5*, 1338–1349.

Noss, R. F. (1990). Indicators for Monitoring Biodiversity: A Hierarchical Approach. *Conservation Biology*, *4*, 355–364.

Pereira, H. M., Ferrier, S., Walters, M., Geller, G. N., Jongman, R. H. G., Scholes, R. J., … Cardoso, A. C. (2013). Essential biodiversity variables. *Science*, *339*, 277–278.

Perino, A., Pereira, H. M., Felipe-Lucia, M., Kim, H., Kühl, H. S., Marselle, M. R., … Bonn, A. (2022). Biodiversity post-2020: Closing the gap between global targets and national-level implementation. *Conservation Letters*, *15*, e12848.

Piipponen-Doyle, S., Bolam, F. C., & Mair, L. (2021). Disparity between ecological and political timeframes for species conservation targets. *Biodiversity and Conservation*, *30*, 1899–

1912.

Saterson, K. A., Christensen, N. L., Jackson, R. B., Kramer, R. A., Pimm, S. L., Smith, M. D., & Wiener, J. B. (2004). Disconnects in Evaluating the Relative Effectiveness of Conservation Strategies. *Conservation Biology*, *18*, 597–599.

Schmeller, D. S., Weatherdon, L. V., Loyau, A., Bondeau, A., Brotons, L., Brummitt, N., … Regan, E. C. (2018). A suite of essential biodiversity variables for detecting critical biodiversity change. *Biological Reviews*, *93*, 55–71.

Shin, Y.-J., Midgley, G. F., Archer, E. R. M., Arneth, A., Barnes, D. K. A., Chan, L., … Smith, P. (2022). Actions to halt biodiversity loss generally benefit the climate. *Global Change Biology*, *28*, 2846–2874.

Stevenson, S. L., Watermeyer, K., Caggiano, G., Fulton, E. A., Ferrier, S., & Nicholson, E. (2021). Matching biodiversity indicators to policy needs. *Conservation Biology*, *35*, 522–532.

Stevenson, S. L., Watermeyer, K., Ferrier, S., Fulton, E. A., Xiao, H., & Nicholson, E. (2024). Corroboration and contradictions in global biodiversity indicators. *Biological Conservation*, *290*, 110451.

UN-WCMC. (2023). Factsheet—Extent of natural ecosystems. Retrieved April 2, 2024, from Indicators for the Post 2020 Global Biodiversity Framework website: https://www.post-2020indicators.org/metadata/headline/A-2

Valdez, J. W., Callaghan, C. T., Junker, J., Purvis, A., Hill, S. L. L., & Pereira, H. M. (2023). The undetectability of global biodiversity trends using local species richness. *Ecography*, e06604.

Vicente, J. R., Vaz, A. S., Roige, M., Winter, M., Lenzner, B., Clarke, D. A., & McGeoch, M. A.

(2022). Existing indicators do not adequately monitor progress toward meeting invasive alien species targets. *Conservation Letters*, *15*, e12918.

Watermeyer, K. E., Guillera-Arroita, G., Bal, P., Burgass, M. J., Bland, L. M., Collen, B., … Nicholson, E. (2021). Using decision science to evaluate global biodiversity indices. *Conservation Biology*, *35*, 492–501.

Watts, K., Whytock, R. C., Park, K. J., Fuentes-Montemayor, E., Macgregor, N. A., Duffield, S., & McGowan, P. J. K. (2020). Ecological time lags and the journey towards conservation success. *Nature Ecology & Evolution*, *4*, 304–311.

Supplementary material

S1. Scenarios of biodiversity change and indicator use cases

Each group was asked to select one of three scenarios of biodiversity change to consider when drawing the space-time coverage of each indicator on their grid (Table S1). The consensus results presented in the main text (Fig. 2 and Fig. 3) do not discern between these scenarios because the coverage of indicators on the space-time grids did not strongly differ between Scenarios 1 and 2 (Fig. S1), and Scenario 3 was not discussed as it was only addressed by one group.

Each group was also asked to discuss one of two use cases when placing indicators on the space-time grids: (1) monitoring, or (2) decision-support. The results in the main text do not differentiate between use cases, because the consensus from the grids was very similar between use cases as well.

Table S1: Scenarios of biodiversity change that were discussed during the workshop.

Scenario	Description
1	Rapid habitat conversion of native ecosystems to a degraded state or converted to non-natural ecosystems with increasing habitat fragmentation and **early signs of population and ecosystem function decline**.
2	Increased protection and effective management have **improved the outlook** for biodiversity with rebounding wildlife populations and ecosystem health.

3	Rapid changes in **disturbance regimes** (e.g. increased fire frequency, extreme heat events) causing potential ecosystem shifts, but modelled projections are **uncertain** as to how this might happen.

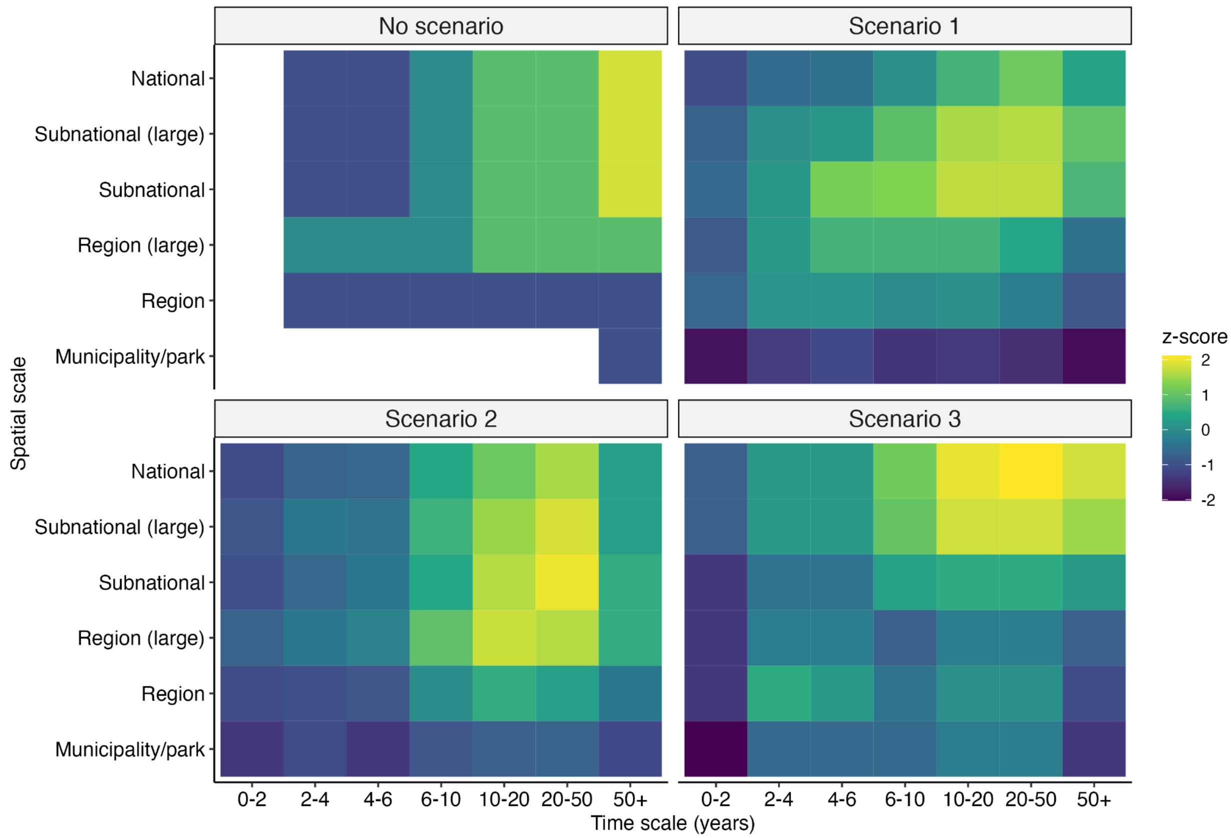

Figure S1. Consensus from the 24 grids drawn by the 12 groups of workshop participants for each scenario. Each grid shows the coverage of the indicator suite to support decisions and monitor biodiversity change from local to national scales, and from short-term (0-6 years) to long-term (50+ years) scales, for the scenarios described in Table S1. "No scenario" shows the results from one grid which was not labelled by workshop participants. "Scenario 1" contains 11 grids, "Scenario 2" contains 11 grids, and "Scenario 3" contains 4 grids (done by 1 group).

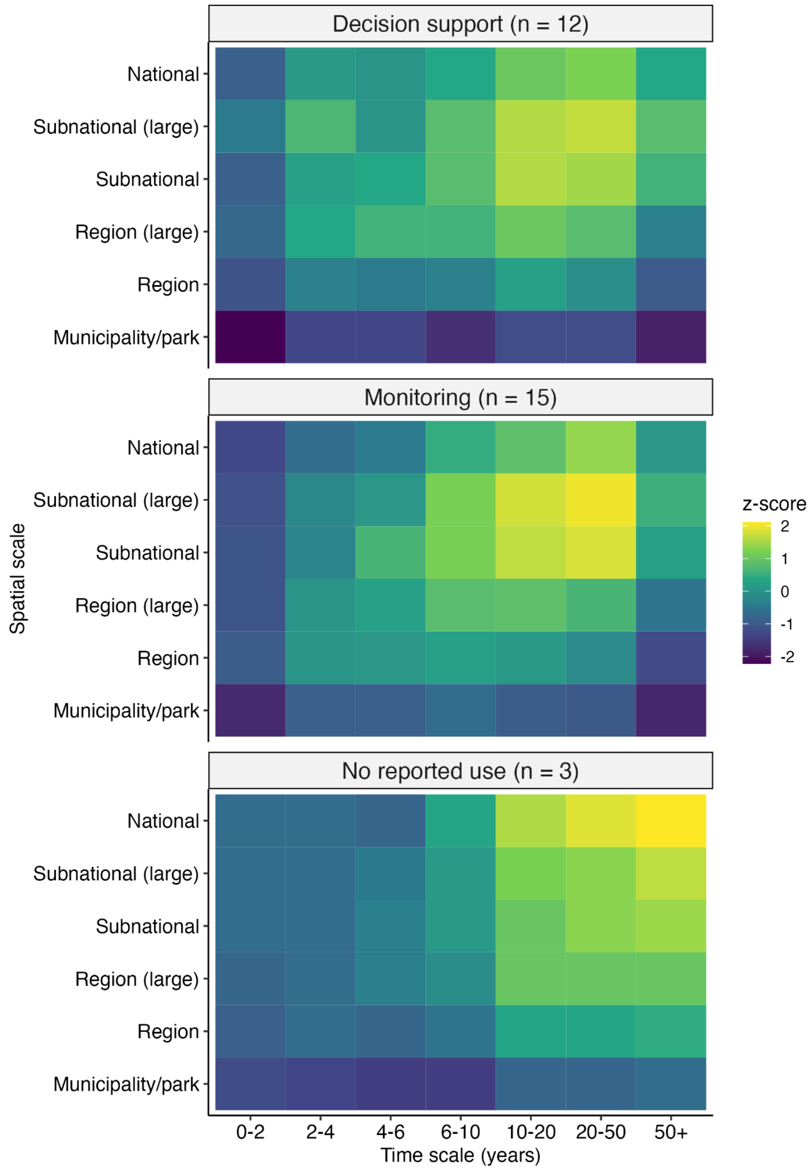

Figure S2. Consensus from the 24 grids drawn by the 12 groups of workshop participants for each use case. Each grid shows the coverage of the indicator suite to support decisions and monitor biodiversity change from local to national scales, and from short-term (0-6 years) to long-term (50+ years) scales. "No reported use" shows the results from three grids which were not labelled by workshop participants.