Sufficiency and Suitability of Global Biodiversity Indicators for Monitoring Progress to 2020 Targets

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Keywords
Aichi Targets; biodiversity; biodiversity indicators partnership; conservation; convention on biological diversity; indicators; strategic plan.

Abstract
Biodiversity indicators are widely used tools to help determine rates of biodiversity change and the success or failure of efforts to conserve it. However, their sufficiency and suitability in providing information for decision-makers is unclear. Here, we review the indicators brought together under the Biodiversity Indicator Partnership to monitor progress towards the Aichi Targets to determine where there are gaps. Of the 20 Aichi Biodiversity Targets, Targets 2, 3, and 15 are missing indicators entirely. Scoring the indicators in relation to their alignment, temporal relevance and spatial scale shows additional gaps under Targets 1, 13, and 16–20. Predominately, gaps were found to be socio-economic in nature (i.e., benefits, pressures, and responses) rather than status-related (i.e., states), principally due to a poor alignment between the indicator and the text of the Aichi Target. Hence, it is critical that existing indicators are properly resourced and maintained and new indicators developed to be able to effectively monitor biodiversity and its influencing factors to 2020 and beyond.

Introduction
Indicators have become essential for effective policy formation and political decision-making (Mace & Baillie 2007; Nicholson et al. 2012). In 2010, The Parties to the Convention on Biological Diversity (CBD) committed to a significant reduction in the rate of biodiversity loss by 2010 (Conference of the Parties to the Convention on Biological Diversity 2010); however, tracking progress towards the target was hindered by an underdevelopment of, and underinvestment in, biodiversity indicators (Walpole et al. 2009). In 2010, renewed commitments to halt biodiversity were made as the new Strategic Plan for Biodiversity 2011–2020 was adopted. The plan is supported by 20 “Aichi Biodiversity Targets” (henceforth, Aichi Targets) covering “pressures” on, “states” of, and “benefits” from biodiversity and “responses” to the biodiversity crisis. As the new Strategic Plan considers a number of subjects not covered under the 2010 Target (Conference of the Parties to the Convention on Biological Diversity 2010) the sufficiency and suitability of global biodiversity indicators for monitoring progress remains open to debate.

Whilst a large number of biodiversity indicators exist, differing levels of spatial and/or temporal coverage means that not all are applicable to monitor progress toward the 2020 target (Tittensor et al. 2014). The Biodiversity Indicators Partnership (BIP) is the principle mechanism supporting the delivery of indicators for international governance via the CBD’s Strategic Plan (e.g., Conference
of the Parties to the Convention on Biological Diversity 2010). Since its establishment, BIP partner organizations and their indicators have been successfully mobilized to track how biodiversity has changed (Butchart et al. 2010; Tittensor et al. 2014); demonstrate that biodiversity loss is continuing (e.g., WWF 2014; Regan 2015); and show that society needs to mobilize greater resources, or allocate them more effectively, to tackle the biodiversity crisis (Tittensor et al. 2014). Nevertheless, despite their widespread use, the current set of global biodiversity indicators that form the BIP remain largely unevaluated in their capacity to report meaningfully on global targets (Collen & Nicholson 2014).

The aim of this study is to objectively assess the sufficiency and suitability of the global BIP indicator suite, highlighting areas in need of additional development, thereby aiding data-informed decision making and effective conservation interventions.

**Methods**

The current BIP indicator suite (http://www.bipindicators.net/globalindicators) was scored according to three criteria: their alignment to the relevant Target, temporal relevance to the Strategic Plan and their spatial coverage. Given the broad and multifaceted nature of the Aichi Targets, scoring was conducted against target “elements” which represent discrete textual aims within each Target. The elements are based on those used in Global Biodiversity Outlook 4 (Secretariat of the Convention on Biological Diversity 2014) (Table S1). This scoring scheme enabled us to identify two types of information insufficiency: (1) situations where there are no suitable indicators and (2) situations where there is one or more indicators but their poor alignment, spatial coverage or temporal relevance limit their utility.

1. **Alignment to Aichi Target:** how well does an indicator align to the text of the relevant Aichi Biodiversity Target elements? The level of alignment for each indicator with a Target element varies; where there was overlap in the indicators the scores came from Tittensor et al. (2014), for new indicators the same method as used in Tittensor et al. (2014) (Table S2) was repeated in order to assess qualitatively whether we consider them to be of “low,” “medium,” or “high” alignment (Table 1).

2. **Temporal relevance:** are there sufficient pre- and post-2010 data points and planned data points for the period 2010–2020 to enable accurate assessment of implementation of the Strategic Plan? Scoring was based upon the number of annual data points available during the Strategic Plan period. Estimates of the number of data points available from 2011 to 2020 were based on the temporal spacing of data points to date and in some cases in consultation with indicator partners (Table 1).

3. **Spatial coverage:** what is the spatial scale of the indicator? The scores given to each of the indicators were assigned according to the criteria adopted in Tittensor et al. (2014) (Table 1).

The scores from each criteria were combined for each indicator, and then across indicators, to produce one score per Aichi Target. Combined scores were generated per indicator based on weightings: alignment scores were multiplied by 2, temporal relevance by 1.5 and spatial scores were unweighted (see Table S2 for justification). In order to aid visualization, the indicators were categorized as high, medium, or low relative to the scores of the other targets using the Natural Jenks method (Jenks 1967).

**Results**

For three of the twenty Aichi Targets (2, 3, and 15) there were no global indicators within the Biodiversity Indicator Partnership (BIP) (Figure 1), all of which are related to “responses” to biodiversity loss. Aichi Target 2 considers integrating biodiversity values into development and poverty reduction processes, while Aichi Target 3 aims to eliminate or reform incentives that are harmful to biodiversity. Aichi Target 15 relates to ecosystem resilience, conservation, and restoration. Of the 54 elements that form the 20 Aichi Targets, under half (46%) have indicators: Aichi Target 13 (genetic diversity) has the highest proportion of gaps, with only one of its five elements having an indicator (Figure S1).

For the seventeen Aichi Targets that do have indicators, the indicators varied in regards to their alignment to the text of the Aichi Targets, spatial coverage and temporal relevance:

**Alignment:** Thirteen Aichi Targets had at least one indicator that aligned well with the corresponding text (65%) (Figure 2), while all of the indicators that represent Aichi Targets 8, 14, 18, and 19 had low alignment. For example, the Ocean Health Index, Red List Index (species used for food and medicine) and the Red List Index (pollinating species) are indicators under Aichi Target 14 but were not considered robust proxies for the Aichi Target text. Over the 54 elements, 12 (33%) of the indicators scored low in regards to alignment; 5 (9%) had a medium score; 18 (22%) scored highly, and 19 (35%) had no indicators. (Figure S1).

**Temporal relevance:** Sixteen of the Aichi Targets had at least one indicator with high temporal relevance and...
Table 1 The scoring system applied through this review to support indicator gap analyses. Amended from Tittensor et al. (2014)

| Score          | Alignment to Aichi Target element                                                                 | Temporal relevance                                                                 | Spatial coverage |
|----------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------------|
| High/good      | The level of alignment for each indicator with an Aichi Target element was determined (qualitatively) to be of “low,” “medium,” or “high” alignment | According to current trends 5 ≥ data points are projected between 2010 and 2020. This gives greater sensitivity to change than indicators that scored medium | “Good,” as defined by Tittensor et al. (2014): 5 + continents (more than 20 countries total) |
| Medium/moderate| The level of alignment for each indicator with an Aichi Target element was determined (qualitatively) to be of “low,” “medium,” or “high” alignment | According to current trends 3–4 data points are projected between 2010 and 2020. A trend can be inferred but with large uncertainty | “Moderate,” as defined by Tittensor et al. (2014): 3–4 continents (more than 10 countries total), 5 + continents (fewer than 20 countries total) |
| Low/poor       | The level of alignment for each indicator with an Aichi Target element was determined (qualitatively) to be of “low,” “medium,” or “high” alignment | According to current trends 2 ≤ data points are projected between 2010 and 2020. This is insufficient information to analyze a trend | “Poor,” as defined by Tittensor et al. (2014): 1–2 continents (no matter how many countries), 3–4 continents (less than 10 countries total) |

Figure 1 The score for the global indicators available for each Aichi target combined for alignment, temporal relevance, and spatial coverage.

19 (35%) had no indicators (Figure 2), with the indicator for Aichi Target 18 (Index of Linguistic Diversity) scoring low due to the more irregular frequency in which it is updated. At the element level, 5 (9%) indicators scored low; 2 (4%) had a medium score; 28 (52%) scored highly, and 19 (35%) had no indicators. (Figure S2).

Spatial coverage: Sixteen Aichi Targets had at least one indicator with high spatial coverage (80%) (Figure 2). Aichi Target 1 (awareness of biodiversity) has a single indicator, which scored “low” for spatial coverage. The indicator in question is the Biodiversity Barometer, which uses data from only six countries—Brazil, China, France, Germany, the United Kingdom, and the United States. At the element level, 4 (7%) of the indicators scored low in regards to spatial coverage; 2 (4%) had a medium score; 29 (53%) scored highly; and 19 (35%) had no indicators (Figure S3).
Combined scores

Three Aichi Targets had relatively high indicator sufficiency scores (6, 9, and 11) whilst ten had relatively low scores (1, 5, 8, 10, 13, 16, and 17–20), with the largest number (four) sitting under Strategic goal E “Enhance implementation through participatory planning, knowledge management and capacity building.” For a number of targets (13, 16, 17, and 20), a low score was a result of the Aichi Target having only one indicator (Figure 1). A separate analysis was conducted in which weightings were not applied in order to test the sensitivity of the findings, the results show the relative score for each Aichi Target is almost identical with the only expectation being Aichi Target 11, which was classified as “medium” when no weightings were used as opposed to “high” using weightings (Supplementary material 2).

Discussion

The rapid development of online databases, indicators and indicator partnerships continues to improve our ability to quantify progress toward international biodiversity targets (Collen & Nicholson 2014; Tittensor et al. 2014). Nevertheless, there remain three Aichi Targets (2, 3, and 15) for which no global indicators have been developed. For Aichi Target 2, the difficulty lies in the undefined nature of “biodiversity values,” the challenge of measuring integration and the lack of universally accepted ecosystem accounting and reporting frameworks. In particular, the diverse nature of national and subnational processes and plans relating to development, poverty reduction and planning poses a challenge. For many countries, these will not form just three distinct documents but may encompass a huge number of different policies, plans and strategies, hindering both national level reporting and the development of a uniform global indicator. With respect to Aichi Target 3, the majority of incentives occur at the national to regional scale, and again may vary greatly in nature. Global indicators for both these targets would therefore need to collate together information on various national/regional incentives relevant to each individual country, which would be a resource-intensive activity. For Aichi Target 15, a major challenge is that the target is so vague—what does resilience relate to, do we mean resilience of ecosystems to climate change or to threats in general? Either way the concepts are multifaceted and broad, not lending themselves to easy measurement. Furthermore, the definition of degradation is also difficult and not standardized, and will vary between ecosystem types (Leadley et al. 2014).

For those seventeen Aichi Targets with indicators, a sizeable proportion had shortcomings relating to their alignment, spatial coverage or temporal relevance. That is, while we do have indicators, their ability as useful proxies remains insufficient, thereby leading to a limited...
or circumscribed view of progress. Specifically, indicators for Aichi Targets 1, 13, 16, 17, 18, 19, and 20 need to be enhanced in order to improve our ability to monitor biodiversity and to obtain a comprehensive picture of status and trends that can accurately inform decision-making. For the majority of these targets, the primary challenges lie in their openness to diverse interpretations due to both their unspecific nature and their broad and multifaceted coverage. For example, Target 15 covers resilience, degradation, climate change mitigation, and the contribution of biodiversity to carbon stocks; these are four, in many ways distinct and not necessarily related, ideas. As such one recommendation that comes from this work is that future target wording should be as unambiguous as possible and should at least theoretically be possible to measure.

The majority of gaps and insufficiencies relate to our ability to track sociological / economic process (i.e., benefits, pressures and responses) rather than the status of biodiversity. In particular, there is a clear gap in our ability to track and monitor the effectiveness of capacity building, with all indicators under Strategic Goal E (Enhance implementation through participatory planning, knowledge management and capacity building) scoring poorly. This differentiation likely reflect the long history of biologists collecting information compared to those disciplines seeking to link socio-economic factors to biodiversity (Balmford et al. 2005). A lack of capacity at the national level in formulating regulatory policies for biodiversity conservation has long been a significant challenge (Adenle 2012). Furthermore, insufficient funding has been shown to be one of the main barriers to achieving the 2010 Target (Waldron et al. 2013); based on the results of this study, it is apparent that in the context of biodiversity indicators, similar challenges remain.

Conclusion

The indicators brought together under the BIP provide the best possible framework from which to monitor progress toward the Strategic Plan for Biodiversity 2011–2020, with at least one global indicator available for 17 of the 20 Aichi Biodiversity Targets at present. Multipurpose Indicators, such as the Red List Index, were found to be of particular value due to their ability to be disaggregated to report against various targets. This review has highlighted the following issues and recommendations. In addition to adequately maintaining and resourcing the existing indicators, there is a need to develop more meaningful indicators to track societal and demographic changes, which are driving forces that exert pressures on the environment. Furthermore, building capacity, finance, and technological innovation, in conjunction with providing an enabling policy environment, is a particular need. In order to effectively overcome these limitations and challenges, the international biodiversity community and policy and decision makers need to come together, to work across multiple sectors and jointly develop solutions to ensure all aspects of quantifying international biodiversity policy effectiveness are covered to 2020 and beyond.

Acknowledgments

We are grateful to all the individuals and organizations who contribute to the BIP indicators, which underpin our analysis. The writing of this article was financed by the Federal Office for the Environment (FOEN), Switzerland, UNEP and the European Commission.

1. With the exception of “Trends in potentially environmentally harmful elements of government support to agriculture (producer support estimate),” which was added to the BIP subsequent to the completion of this manuscript.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher’s web site:

Figure S1. The relative Aichi Target scores with and without the weighting factor.

Table S1. The breakdown of each Aichi Target into its respective elements and their alignment, temporal relevance and spatial coverage scores

Table S2. Justification of the multipliers used in the analysis

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