November 2021. Version 1.0

Indicator metadata sheet

Indicator metadata form for compilation of data relating to headline indicators proposed in the first draft of the monitoring framework for the post-2020 global biodiversity framework

1. Indicator name

Insert full indicator name and number [number to be populated after the adoption of the post-2020 global biodiversity framework]

Species Habitat Index (SHI)

2. Date of metadata update

Insert date of metadata update

February 2022

3. Goals and Targets addressed

Please provide details about the proposed goals and targets of the first draft post-2020 global biodiversity framework for which the indicator will measure progress in the first draft of the post-2020 global biodiversity framework

3.a Goal

Provide the corresponding draft goal name, draft goal number, or N/A

Goal A. The integrity of all ecosystems is enhanced, with an increase of at least 15% 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% of genetic diversity within all species maintained.

3.b Target

Provide the corresponding draft target name, draft target number, or N/A

4. Rationale

Description of the purpose and rational behind the indicator, noting its relevance to the corresponding draft goal or target

The integrity of ecosystems relies on the sustained ecological processes by the species that define them. Changes in the quality and connectivity of habitats that affect the health of systems' species impacts this integrity and ecosystem resilience. The SHI measures changes in ecosystem integrity as the degree of change in component species and their associated ecological processes and functions.

The index captures alterations to the quality and connectivity of habitats at the level of single species and at fine spatial scale, addressing single square kilometer assemblages. When aggregated over a larger geographic unit (e.g., landscape, seascape, mountain region, ecological region, or country), SHI can provide a compound measure of an area's ecological integrity and connectivity. When evaluated over species' geographic ranges, the SHI also informs about trends in the health of species populations and potential changes in their genetic diversity.

The SHI complements the other Goal A Headline Indicators through its capture of key aspects (connectivity, integrity, population distribution, and population size) and its comprehensive relevance to all Goal A elements (Table 1). The SHI has primary or unique pertinence to four of the eight listed elements, and primary or secondary pertinence to the other four. Its combination of biodiversity observations with standard, near-global remote sensing products supports immediacy (e.g., annual updating), geographic comparability and near-global representation, disaggregation to kilometer- and landscape scale, species-level interpretation, and independent national computation.

Table 1: Relevance of the SHI to the different components and elements of Goal A.

Goal Milestones, Components		**SHI**	**SHI Relevance**
A1: Natural systems	Area	Captures changes in the area available to the system's individual species in support of its ecological processes.	Secondary
	Connectivity	The SHI measures changes in the connectivity of ecosystems, and specifically the connectivity associated with ecological processes.	Primary
	Integrity	The SHI provides a composite measure of change in the ecological intactness of assemblages	Primary
A2: Species Populations	Extinction rate	The count of species with SHI equal to 0 over time provides an estimate of extinction rate..	Primary / Secondary
	Extinction risk, Threat status	Increases in species extinction risk and threat status are a concave-upward function of decreasing suitable area and connectivity, the two components of SHI.	Secondary
	Population abundance (size)	Changes in species population sizes are directly related the area and connectivity of their habitats, as measured by SHI.	Primary
	Population Distribution	The area component of SHI directly measures changes in population distribution.	Primary
A3: Species Genetics	Genetic diversity	SHI provides the proposed main genetic diversity indicator "Proportion of populations, or geographic range, maintained within species" to assess potential loss of unique adaptations.	Primary / Secondary

Milestone A.1:

Net gain in the area, connectivity and integrity of natural systems of at least 5 per cent.

For this milestone SHI addresses all milestone elements, and in particular measures connectivity. It measures changes to the many units, i.e., species, that define ecosystems and drive their ecological processes and integrity. For any defined area, the SHI assesses temporal change in hundreds or thousands of species and provides a compound signal of change in ecosystem integrity.

Indicator "A.0.1 Extent of selected natural and modified ecosystems" is poised to deliver a basic but important capture of the area element of this milestone. Remote sensing enables a high-resolution delineation and tracking of ecosystem modification and areal change. Expert-based quality metrics could add further relevance to indicator A.0.1. But necessarily based on single geographic layers of abutting ecosystems (and thus a single dimension), the A.0.1 extent measure is naturally limited in the capture of ecological connectivity and integrity.

The SHI shares similarity with indicators of fragmentation focused on select ecosystems (e.g., forest fragmentation, river fragmentation, mangrove fragmentation), with a more direct measurement of ecological integrity. For example, the change in the connectivity of a region's forest ecosystems as measured with the forest fragmentation index would essentially be the same as that measured with the SHI applied to a single forest species inhabiting that full region (assuming the same landcover change products are used). By including many different forest species of the region and thus accounting for their many functions and roles for the ecosystem, the SHI captures connectivity with direct relevance for the overarching aspiration of Goal A, the ecological integrity of ecosystems.

Milestone A.2

The increase in the extinction rate is halted or reversed, and the extinction risk is reduced by at least 10%, with a decrease in the proportion of species that are threatened, and the abundance and distribution of populations of species is enhanced or at least maintained.

The SHI, specifically through the area component, uniquely and primarily addresses the second portion of Milestone A.2 by capturing trends in species population abundance and distribution.

For the first milestone part, Indicator '*A.0.3 Red list index'*, and in particular national red-listing efforts, the SHI provides a periodic assessment of 'Extinction risk' and 'Threat status' and, as possible, through expert networks carefully assess "Extinct" status. Species-level SHI values and maps can offer vital information, supporting expert threat assessments by providing temporal immediacy, regional/national specificity, and geographic specificity.

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.

In the absence of comprehensive genetic sampling to characterize separate populations and their genetically effective sizes, SHI offers a scalable alternative method to monitor loss of genetic diversity. SHI directly measures the "Proportion of populations, or geographic range, maintained within species", one of two main indicators for measuring genetic diversity recommended by the GEO BON Genetic Diversity Working Group, with support from IUCN Conservation Genetics Specialist Group and others.

The indicator 'A.0.4 The proportion of populations within species with a genetically effective population size > 500' can offer a more direct quantification of genetic diversity when sufficient, range-wide genetic sampling allows. Where sufficient genetic data are lacking, estimates of changes in the minimum sizes of (connected) populations are recommended as alternative which the SHI area and connectivity components address. While or where range-wide genetic sampling for remains limited to a very specific subset of species, the SHI can be a proxy for trends in genetic diversity for a larger and more representative portion of biodiversity.

Definitions, concepts and classifications

5.a Definition:

Precise definition of the indicator, including references to standards and classifications. The indicator definition should be unambiguous and in expressed in universally applicable terms. It must clearly express the unit of measurement (proportion, dollars, number of people, etc.).

The SHI is given as the average size and connectivity of species' suitable habitat in a specified geographic unit (e.g., country) at a given point in time relative to the reference period (Power & Jetz 2019, Hansen et al. 2021, Jetz et al., 2021). The index is calculated as an aggregate of single 'species habitat scores' (SHS) and is expressed relative to a baseline of SHI = 100. For example, a 6% and 8% decrease, respectively, in habitat size and connectivity of Species A would result in an SHS of 94 for that species (average of 96, for size, and 92, for connectivity). If Species B in a region has SHS = 102 and Species C has SHS = 98, the resulting SHI for the region based on these three species is 98 (average of 94, 102, and 98), a decrease of two percentage points compared to a baseline SHS of 100. In practice, scores from hundreds or thousands of species are aggregated to inform the SHI of a region, and the SHI is thereby sensitive to change in a range of associated functions and processes. To explore patterns, see https://mol.org/indicators/habitat; e.g. https://mol.org/species/habitat-trend/Cephalophus_zebra.

For country reporting, the SHI can additionally take national stewardship for native species into account, i.e., weight more strongly changes in species and ecosystem aspects that occur in few or no other countries. Compared to the *National SHI*, defined as the arithmetic mean of a country's SHS values, *Steward's SHI* is based on a weighted average of SHS values, with the proportion of the global population a country is estimated to hold as weights.

The SHI is calculated and validated using species occurrence data combined with environmental change data informed by remote sensing. Calculations use best-possible predictions of species geographic distributions (Species Populations EBVs), based on a variety of sources combined with species habitat information.

The SHI can be calculated independently with national or subnational information, such as national biodiversity monitoring data or national land-cover products. A full suite of annual country-level indicator values and extensive species-level data and metadata supporting it are made available through GEO BON and its associated Species Population EBV platform Map of Life, and parties can readily use these directly for their reporting or use them to augment their own calculations.

SHI subsets can address specific taxonomic or functional groups, migratory species, groups characteristic of certain habitats and ecosystems (forests, alpine zone, coral reefs, mangroves, etc.), groups of rare or threatened species or groups with particularly rapid recent habitat changes. Such subsets allow measuring change in biological integrity as experienced by these specific systems.

5.b Method of computation

Explanation of how the indicator is calculated, including mathematical formulas and descriptive information of computations made on the source data to produce the indicator (including adjustments and weighting). This explanation should also highlight cases in which mixed sources are used or where the calculation has changed over the time (i.e., discontinuities in the series). If there is an existing standard or manual, please include a link here.

SHI is calculated in a two-step process. First Species Habitat Scores are calculated, and then these are aggregated to derive the Species Habitat Index.

I. Species Habitat Scores:

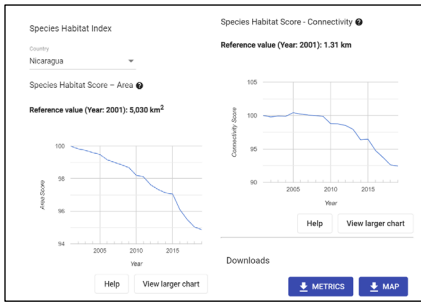
Let s_{hi} represent the suitability of pixel *h* for species i, which is varying from 0 to 1, which could be expressed in binary form (0 or 1). The size of suitable habitat area in region *j* for species i, A_{ji}, is then given by the summed product of the pixel-level suitability of *h* in *j* and the pixel size *a* (assumed constant, e.g., 1 km^2): $A_{ij} = a \sum_h s_{hi}$

The connectivity of suitable habitat area for species *i* in region *j*, C_{ij}, is given by the GIS fragmentation (GISfrag) metric calculated over a binary version of the pixel-level suitability map. First, for each of the *p* suitable pixels the distance d_{hi} to the closest edge pixel is calculated (edge includes any non-passable, natural or artificial barriers). The GISfrag metric is the average of these distances: $C_{ij} = \frac{\sum_j d_{hi}}{p}$

For a particular year *k* both metrics are then set relative to the reference year of k = 1. The area score (*AS*) and connectivity score (*CS*) for year *k* is given as:

$$AS_{jk} = 100 \frac{(A_{j1} - A_{jk})}{A_{j1}} \text{ and } CS_{jk} = 100 \frac{(C_{ji} - C_{jk})}{C_{j1}}$$

The Species Habitat Score *SHS* for species *i* in region *j* and year *k* is then defined as the mean of these Area and Connectivity scores for that year: $SHS_{ijk} = \frac{(AS_{jk} + CS_{jk})}{2}$



Species Habitat Scores: Area Score (AS) and Connectivity Score (HS) for an example species (Sumachrasti's Harvest Mouse) and country. See here for details, including trends for other countries, maps, and metadata.

II. Species Habitat Index:

National SHI of country *j* in year *k* is given as the average of the *n* Species Habitat Scores in that year: $SHI_{jk} = \frac{\sum_i SHS_{ijk}}{n}$

Steward's SHI is calculated similarly, but as weighted average using national species' stewardship weights. Let the global habitat-suitable range area of species i in the reference period be $A_i = \sum_j A_{ij}$.

The *stewardship weight* of country j for species i is then given by $w_{ji} = \frac{A_{ij}}{A_i}$,

and represents the proportion of the global habitat-suitable range of species i found in country j.

Steward's SHI of country j in year k is then simply given as a weighted average using these stewardship weights: $SHI_{jk} = \frac{\sum_i w_{ij} SHS_{ijk}}{\sum_i w_{ij}}$

5.c Data collection method

Description of all methods used for data collection. This description should include, when applicable, the questions used to collect the data, the type of interview, the dates/duration of fieldwork, the sample size and the response rate. Hyperlinks to methodologies are acceptable

See above for description of data inputs. These include primary species occurrence data, literature-based or model-supported species distribution predictions, literature or data-derived habitat associations, land cover and ecosystem extent change information.

Independent national SHI calculations can replace the nationally disaggregated global calculations. Indicator data for each species and country combination are available through GEO BON (see above) and can either partly or fully be replaced. Countries can use national biodiversity monitoring or map datasets and national land cover data and apply the same methodology. National SHI values calculated with national data consistently over time can be fully interpreted temporally and harmonized with global, disaggregated SHI values. To support harmonization and interpretation of national difference, national calculations should include metadata on the species and datasets used.

5.d Accessibility of methodology

Note whether the methodology for the indicator and the underlying data are published in a peer reviewed location that can be accessed, and the methodology can be repeated by other scientists or agencies with the same overall result obtained. For "global indicators" please note whether a methodology is available for use at national or regional scales

The Species Habit Index was peer-reviewed and published in Powers & Jetz (Nature Climate Change, 2019), with further peer-reviewed descriptions and extensions in Hansen et al. (2021) and Jetz et al. (2021). The methodology has been used in the IPBES global assessment and the indicator is part of the Biodiversity Indicators Partnership (BIP) indicator suite. See reference list. For additional description of the SHI methodology see CBD/WG2020/3/INF/6.

The methodology is laid out in further detail in this present document to support full replicability at the national and regional scale. The methodology can be repeated by other scientists and agencies. Use of the same publicly available data inputs will yield the same overall results. The same methodology can be used at national and regional scale with partially or fully separate data inputs, such as national biodiversity or land cover data. It is equally applied to coastal and marine data.

5.e Data sources

Description of all actual and recommended sources of data

At the global scale:

Map of Life (MOL, https://mol.org/indicators/habitat); habitat-suitable range maps, habitat-suitable range area and connectivity calculations, country SHS values.

Global Biodiversity Information Facility (GBIF, https://www.gbif.org) through its national nodes.

European Space Agency (ESA); e.g., through its global CCI land cover product https://www.esa-landcover-cci.org.

NASA/USGS/U Maryland: e.g. through the Landsat Satellite program supporting the production of annual land cover and tree cover data (https://landsat.gsfc.nasa.gov).

Marine and coastal habitats: maps of ecosystem extent as available for coral reefs, mangroves, and other marine ecosystems and seascapes. Maps of human impacts (Halpern et al. 2015).

River barriers (Grill et al. 2015, 2019), with non-passable dams defining range edges for, e.g., freshwater fishes.

At the national scale:

As available: National biodiversity occurrence and map data, National land cover products,

5.f Availability and release calendar

Please note whether the indicator is available now or in development. If in development, please state the year it will be available. Additionally, state how often the indicator will be updated with additional data. (e.g. annually, every five years etc). If the indicator is not operational, please add a short description of how it is being made operational.

The indicator is available now. New data on habitat changes are available annually at the global scale from standard remote-sensing supported products. Biodiversity records provided through GBIF and other partners are updated on an ongoing basis, sub-annually. GEO BON through its partner platform Map of Life is committed to extending the data coverage to many more species groups, and specifically to marine, coastal, and freshwater groups, and to delivering standardized SHI products for countries annually. Countries using national data may select different time intervals for updates.

5.g Time series

Date range for which indicator is available, e.g. 1993 – 2021

2001-2020 (for a more limited version: 1993-2020)

5.h Data providers

Identification of data provider(s), where relevant noting any national data providers. Specify the organisation(s) responsible for producing the data.

See also data sources.

At the global scale:

GEO BON infrastructure Map of Life (MOL, https://mol.org/indicators/habitat); habitat-suitable range maps, habitat-suitable range area and connectivity calculations, country SHS and SHI values.

Global Biodiversity Information Facility (GBIF, https://www.gbif.org) through its national nodes

European Space Agency (ESA); e.g. through its global CCI land cover product https://www.esa-landcover-cci.org.

NASA/USGS/U Maryland: e.g. through the Landsat Satellite program supporting the production of annual land cover and tree cover data (https://landsat.gsfc.nasa.gov)

At the national scale:

As available

National biodiversity occurrence and map data

National land cover products

5.i Data compilers

Organisation(s) responsible for compilation of this indicator [if relevant, at the national level Global/International context only: Description of how missing values for individual countries or areas are imputed or otherwise estimated by international agencies to derive regional or global aggregates of the indicator].

GEO BON

The indicator is calculated from Species Population Essential Biodiversity Variables (EBVs). Species Population EBVs are based on globally available biodiversity data, e.g., as provided through the Global Biodiversity Information Facility (GBIF), and global satellite remote sensing products, as provided through NASA and European Space Agency, and calculated and provided through GEOBON infrastructure Map of Life (MOL). The global datasets combined with the indicator standard methodology enable predictions for any country that can then support global aggregation.

5.j Gaps in data coverage

Please note any gaps in the data coverage for this indicator (e.g. taxonomic, thematic, or geographic data gaps)

SHI is currently based on several tens of thousands of terrestrial vertebrate species that characterize all land ecosystems. The inclusion of select invertebrate and plant groups is in progress.

SHI calculations are in development for marine ecosystems and expected for late 2022, based on ca. 13,000 marine fish and mammal species (see Rinnan et al., 2021). Currently available inputs on habitat change address coral reefs, mangroves, seagrass (see Goal A ecosystem extent indicator) and from Halpern et al. (2015) for additional human impacts.

The SHI methodology can be applied to freshwater species, with data on dams and other barriers (Grill et al. 2015, 2019) defining edge pixels for species with impacted movement.

5.k Treatment of missing values

Description of the methodology employed for producing estimates for the indicator when country data are not available, including any mathematical formulas and description of additional variables used as input into the estimation process.

Global/International context only: Description of how missing values for individual countries or areas are imputed or otherwise estimated by international agencies to derive regional or global aggregates of the indicator

See 5.i

6 Scale

6.a Scale of use

Indicate if indicator data is applicable at the global, national, regional scale. Specify whether global or regional scale indicators can be disaggregated for national use, and/or whether national data can be collated to form global indicator. Additionally, please mention any plans to nationalise the indicator.

The SHI can be calculated at national scale and aggregated to form a global indicator. Conversely, global scale SHI calculations can be disaggregated to the level of small regions. Generally, the SHI can be calculated and aggregated at spatial levels ranging from 1 km to small regions, countries, biomes, and the whole planet. The SHI can be calculated with purely national data and the methodology allows countries which prefer calculating the SHI independently to nationalize the indicator.

6.b National/regional indicator production

For global indicators, please note whether a national/regional methodology available for use and provide links to any online documentation. Please also specify if underlying data can be accessed and used by countries to produce national indicators.

In addition to using index calculations or species-metrics provided through GEO BON, CBD Parties can directly calculate country-level SHI by leveraging national data, expertise, and biodiversity change assessment capacity. GEO BON, through its working groups, and national and thematic Biodiversity Observation Networks, can provide capacity support. The calculation follows these specific steps:

Step 1: Determine baseline species distributions. At the most basic level, this can include expert range maps, acknowledging their high false presence rate. Preferably, predictions are based on species distribution models (SDMs) that follow best-possible data integration practices and leverage raw occurrence data and remote-sensing supported environmental layers. Parties can develop these national distribution predictions entirely independently or use existing predictions (e.g., https://mol.org/species/range/Cephalophus_zebra), further modified or as provided.

Step 2: Calculate SHS metrics and SHI for the baseline period. The species distribution data are combined with remote-sensing supported layers of environmental conditions, such as land-cover, and the data-driven associations species associations have with them. This delivers continuous or binary pixel-level species habitat suitability for the reference period. Via standard GIS processing, this supports for each species estimates of country-wide i) total suitable habitat area (summed pixel suitability) and ii) habitat connectivity (average distance to edge of suitable habitat area, GISfrag metric [Ripple et al. 1991]). See e.g., https://mol.org/species/habitat-trend/Cephalophus_zebra. These 'Species Habitat Scores' (SHS) are combined for all evaluated species in a country as simple average (National SHI) or as average weighted by the proportion of global population the country is estimated to hold (Steward's SHI).

Step 3: Calculate change in core metrics and SHI. Through standard GIS processing, changes to the baseline levels of suitability of each species-pixel combination are assessed for different time steps using the same or different environmental layers used in Step 2. These layers currently include standard global land-cover and marine change products but can also comprise national change products or a combination of remotely sensed environmental change signals with high spatial and spectral resolution. Distribution gains beyond the baseline (e.g., through extensive restoration or climatic shifts) are addressed through a rerun of Step 1. For each point in time Step 2 calculations are repeated. SHI is given as the average change in area and connectivity, expressed as percent difference to the reference period, set at SHI = 100.

Country 1

Species	*Steward*	Area	Connectivity
A	*0.86*	81	87
B	*1.00*	102	101
C	*0.30*	60	76
National SHI		**81**	**88**
Steward's SHI		**87.8**	**92**

Country 2

Species	*Steward*	Area	Connectivity
C	*0.70*	80	86
D	*1.00*	130	120
National SHI		**105**	**103**
Steward's SHI		**109**	**106**

Example SHI calculation for two countries based on five species. The countries share species C. Steward: country stewardship value, used as weight for Steward's SHI.

6.c Sources of differences between global and national figures

Explanation on the differences between country produced and internationally estimated data on the indicator, highlighting and summarising the main sources of differences.

Differences between nationally and internationally (globally) produced SHI values may arise from the use of different input data sources, e.g. national biodiversity or landcover data.

6.d Regional and global estimates & data collection for global monitoring

6.d.1 *Description of the methodology*

Include any mathematical formulas, used for the calculation of the regional/global aggregates from the country values. Description of the weighting structure used for aggregating country indicator values to regional and global levels.

Aggregation of country-level SHI values to larger regions or the globe is possible through a simple arithmetic mean. Aggregate SHI for a set of *n* countries 1 to *j* in year *k* is given as follows:

$$SHI_k = \frac{\sum_j SHI_{jk}}{n}$$

6.d.2 Additional methodological details

Description of how the data from countries or areas is assembled by custodian international agencies to provide regional and global aggregates. This is distinct from the method of computation section), which looks at how the indicator is compiled at a national level.

Regional and global SHI values are directly aggregated from national values (see 6.d.1). The globally harmonized annual SHI calculation that is provided by GEO BON is conducted at national level and thus provides national, regional, and global values. Nations can additionally apply the same standard SHI methodology to their own datasets. These nationally developed SHI values might not be perfectly comparable among countries that use different national inputs (e.g., land cover maps based on different sources or methodology). But with this caveat in mind regional and global aggregation of such nationally developed SHI information are equally straightforward and a simple average of national values.

6.d.3 Description of the mechanism for collecting data from countries

Include: (i) the official counterpart at the country level; (ii) description of any validation and consultation process; (iii) description of any adjustments with respect to use of standard classifications and harmonization of breakdowns for age group and other dimensions, or adjustments made for compliance with specific international or national definitions.

7 Other MEAs, processes and organisations

7.a Other MEA and processes

Please note where the indicator is already in use (e.g. by the CBD, other MEAs (such as CITES, CMS, Ramsar, UNCCD),SDGs, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services - IPBES).

IPBES

7.b Biodiversity Indicator Partnership

Is the indicator include in those approved and promoted by the Biodiversity Indicators Partnership (Y/N). If Y, insert a link to BIP website.

Y; https://www.bipindicators.net/indicators/species-habitat-index

8 Disaggregation

Specification of the dimensions and levels used for disaggregation of the indicator (e.g., species, taxa, ecosystem, geographic location, income, sex, age group, disability status, etc.)

By species, species group (taxonomic, functional) and any sub-national regional area down to 1 km^2 size.

9 Related goals, targets, and indicators

Description of linkages to other indicators proposed in the first draft monitoring framework

Related indicators

- "Extent of selected natural and modified ecosystems", Headline Indicator for Goal A: The SHI adds important measures of ecological integrity and connectivity within and across ecosystems. More than using basic ecosystem maps to assess patterns, the SHI assesses the ecological quality and connectivity of ecosystems through their biological species elements.

- "Red List Index", Headline Indicator for Goal A: The SHI complements this indicator by providing for the Species Populations milestones an observation-based quantitative measure, temporal immediacy, and national/geographic specificity.

- "The proportion of populations within species with a genetically effective population size > 500'", Headline indicator for Goal A: In the absence of comprehensive genetic sampling to characterize separate populations and their genetically effective sizes, the SHI offers a robust, scalable alternative method to monitor changes in genetic diversity. Specifically, estimates of changes in the minimum sizes of (connected) populations are a recommended avenue for measuring changes in genetic diversity and directly addressed by the Area and Connectivity components of SHI. As range-wide genetic sampling will for some years remain limited to a small and atypical subset of species, the SHI offers a general and effective proxy to monitor trends in genetic diversity for a large and representative portion of biodiversity.

- "Species Protection Index (SPI)", Component Indicator for Target 3: The same map information used in the SHI underpins the SPI which assesses ecological representation in conservation areas.

- Complementary indicators "Forest fragmentation index", etc. The SHI shares similarities with fragmentation indicators focused on select ecosystems, and uses the same input (change in landcover, barriers) to support a more direct measurement of ecological integrity. For example, the change in the connectivity of a region's forest ecosystems as measured with the forest fragmentation index would essentially be the same as that measured with the SHI applied to a single forest species inhabiting that full region (assuming the same landcover change products are used). By including many different forest species of the region and thus accounting for their many functions for the ecosystem, the SHI captures connectivity with direct relevance for the overarching aspiration of Goal A, the ecological integrity of ecosystems.

Related Targets:

- Target 1 (Planning): The SHI measures the success of spatial planning activities in retaining the existence and ecological integrity of natural areas

- Target 2 (Restoration): The SHI measures the success of restoration activities in regaining connectivity and supporting the ecosystems with highest priority for healthy species populations

- Target 3 (Area-based conservation): The SHI measures the effectiveness and success of area-based conservation activities in delivering connected protected area networks and stemming the loss of ecological integrity in protected areas.

- Target 4 (Species management): The SHI measures the success in the recovery and conservation of species and their genetic diversity by assessing improvements in the availability and quality of the specific habitats they require.

- Target 5 (Species use): The SHI subset to species harvested, traded or otherwise used measures the sustainability of these uses with view to the population size and survival of the affected species.

- Target 6 (Invasive Alien Species, IAS): The SHI applied to IAS measures their current or potential future spread, the SHI applied to species known to be impacted by IAS addresses the scope for additional ecological impact.

10 Data reporter

10.a Organisation

Organisation of the contact person(s) for the data or metadata
Yale University with GEOBON

10.b Contact person(s)

Person(s) and email addresses to be contacted with any questions regarding the data or metadata.
GEO BON Secretariat - info@geobon.org Walter Jetz - walter.jetz@yale.edu and GEO BON Secretariat info@geobon.org

11. References

Links to other literature helpful in understanding, interpreting and using the indicator. A maximum of ten references is preferred.

Jetz, W. et al. Essential biodiversity variables for mapping and monitoring species populations. Nature Ecology & Evolution 3, 539-551, https://doi.org/10.1038/s41559-019-0826-1 (2019).

Navarro, L. M. et al. Monitoring biodiversity change through effective global coordination. Current Opinion in Environmental Sustainability 29, 158-169, https://doi.org/10.1016/j.cosust.2018.02.005 (2017).

Hansen, A. J. et al. Toward monitoring forest ecosystem integrity within the post-2020 Global Biodiversity Framework. Conservation Letters n/a, e12822, https://doi.org/10.1111/conl.12822 (2021).

Jetz, W., McGowan, J., Rinnan, D.S., Possingham, H.P., Visconti, P., O'Donnell, B. & Londoño-Murcia, M.C. (2021) Include biodiversity representation indicators in area-based conservation targets. Nature Ecology & Evolution. https://doi.org/10.1038/s41559-021-01620-y

Pereira, H. M., Freyhof, J., Ferrier, S. & Jetz, W. Global Biodiversity Change Indicators. 1-18 (GEO Biodiversity Observation Network, Leipzig, Germany, 2015). https://www.geobon.org/downloads/biodiversity-monitoring/technical-reports/GEOBON/2015/GBCI-Version1.2-low.pdf

Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Service. 1148 (IPBES Secretariat, Bonn, Germany, 2019). https://ipbes.net/global-assessment

Powers, R. P. & Jetz, W. Global habitat loss and extinction risk of terrestrial vertebrates under future land-use-change scenarios. Nature Climate Change 9, 323-329, https://doi.org/10.1038/s41558-019-0406-z (2019).

Jetz, W., Wilcove, D. S. & Dobson, A. P. Projected Impacts of Climate and Land-Use Change on the Global Diversity of Birds. PLoS Biology 5, 1211-1219 (2007). https://doi.org/10.1371/journal.pbio.0050157

Jetz, W. & Thau, D. Map of Life: A preview of how to evaluate species conservation with Google Earth Engine, https://ai.googleblog.com/2015/01/map-of-life-preview-of-how-to-evaluate.html (2015).

Boitani, L. et al. What spatial data do we need to develop global mammal conservation strategies? Philosophical Transactions of the Royal Society B: Biological Sciences 366, 2623-2632, https://doi.org/10.1098/rstb.2011.0117 (2011).

Visconti, P. et al. (2011) Future hotspots of terrestrial mammal loss. Philosophical Transactions of the Royal Society B: Biological Sciences 366, 2693-2702. https://doi.org/10.1098/rstb.2011.0105

Halpern, B. S. et al. (2015) Spatial and temporal changes in cumulative human impacts on the world's ocean. Nature Communications 6, 7615. https://doi.org/10.1038/ncomms8615

Ripple, W. J., Bradshaw, G. & Spies, T. A. (1991) Measuring forest landscape patterns in the Cascade Range of Oregon, USA. Biol Conservation 57, 73-88. https://doi.org/10.1016/0006-3207(91)90108-L

CBD Secretariat (2021). CBD/WG2020/3/INF/6. 24 August 2021, Montreal. https://www.cbd.int/doc/c/2397/5133/3ce87fa6c735a7bf1cafb905/wg2020-03-inf-06-en.pdf

Oliver, R.Y., Meyer, C., Ranipeta, A., Winner, K., Jetz, W. (2021) Global and national trends, gaps, and opportunities in documenting and monitoring species distributions. PLoS Biology 19(8): e3001336. https://doi.org/10.1371/journal.pbio.3001336

Grill, G., Lehner, B., Lumsdon, A.E., MacDonald, G.K., Zarfl, C. & Reidy Liermann, C. (2015) An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales. Environmental Research Letters, 10, 015001.

Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., Babu, S., Borrelli, P., Cheng, L., Crochetiere, H., Ehalt Macedo, H., Filgueiras, R., Goichot, M., Higgins, J., Hogan, Z., Lip, B., McClain, M.E., Meng, J., Mulligan, M., Nilsson, C., Olden, J.D., Opperman, J.J., Petry, P., Reidy Liermann, C., Sáenz, L., Salinas-Rodríguez, S., Schelle, P., Schmitt, R.J.P., Snider, J., Tan, F., Tockner, K., Valdujo, P.H., van Soesbergen, A. & Zarfl, C. (2019) Mapping the world's free-flowing rivers. Nature, 569, 215-221.