

Living Planet Index

Guidance for national and regional use

Version 1.1





This guidance document is one of a series produced with the support of the 2010 Biodiversity Indicators Partnership (2010 BIP) to assist Parties to the Convention on Biological Diversity (CBD) track their progress towards the CBD's 2010 Target. The Living Planet Index (LPI) has been selected as one of the indicators suitable for assessing progress towards and communicating the 2010 Target at a global level. The aim of this document is to provide information to support the calculation and interpretation of the Living Planet Index at the national and regional scales.

The 2010 Biodiversity Indicators Partnership intends this guidance to be a 'living document'. Updated versions will be produced based on users' feedback, and will include lessons learned and new examples of the indicators in use. Jonathan Baillie and Ben Collen of the global LPI consortium are keen to provide advice and collaboration for the design of national and regional LPI databases and calculation of the index. Please send requests for advice and feedback on these guidelines to:

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For information on other indicator guidance documents and the 2010 BIP please see:
www.twentyten.net or contact info@twentyten.net

The 2010 BIP has been established with major support from the Global Environment Facility (GEF).

Citation: McRae, L., Loh, J., Bubb, P.J., Baillie, J.E.M., Kapos, V., and Collen, B. 2008. *The Living Planet Index - Guidance for National and Regional Use*. UNEP-WCMC, Cambridge, UK.

The Living Planet Index

PURPOSE

The Living Planet Index (LPI) is an indicator of change in global biodiversity based on change in population abundance of vertebrate species from all around the world. Biodiversity is perhaps most widely understood at the species level, so as a measure of trends in species abundance the LPI has a high degree of resonance with decision makers and the public and links clearly to ecological process and ecosystem function.

The global LPI database can be disaggregated for subsets of data to:

- show trends in species abundance for particular taxonomic groups;
- show trends in species abundance for particular habitats or biomes;
- identify regions and ecosystems where the abundance of species is changing most rapidly;
- explore trends in abundance of species impacted by different threat processes;
- monitor trends in species listed on conventions such as CITES or CMS.

PLACE IN THE 2010 BIODIVERSITY TARGET FRAMEWORK

The LPI has been adopted by the CBD as an indicator for immediate testing, under the 2010 Target focal area *Status and trends of the components of biological diversity* and the headline indicator *Trends in abundance and distribution of selected species*. It complements directly two other headline indicators within this focal area:

- 1 *Trends in extent of selected biomes, ecosystems, and habitats;*
- 2 *Change in the status of threatened species.*

Disaggregations of the LPI are relevant to three other CBD 2010 target focal areas:

- 1 under *Threats to biodiversity* and the headline indicator *Trends in invasive alien species*, LPIs can be developed to show trends in the impacts of invasive species and their management on biodiversity;
- 2 under the focal area *Sustainable use*, LPIs showing trends in the impacts of use and its management provide a useful measure;

- 3 under the focal area *Ecosystem integrity and ecosystem goods and services* and the headline indicator *Biodiversity for food and medicine*, an LPI showing trends in the status of species used for food and medicine is relevant.

The LPI is constructed from direct counts or estimates of species populations, and therefore provides a basis for assessing the importance of trends in the impact of change in habitat extent, which is in many cases among the underlying causes of change in species populations. Subsets of the LPI can provide a basis for tracking progress under the Ramsar Convention and the Convention on Migratory Species, as well as helping to assess the effectiveness of CITES in reducing the impacts of trade on some endangered species.

BACKGROUND TO THE LPI'S DEVELOPMENT AND SELECTION BY CBD

The LPI was initially developed for the Living Planet Report in 1998 by WWF and WCMC as an attempt to answer the question: how fast are we losing global biodiversity? The underlying dataset was expanded and the index further developed and published in subsequent editions of the WWF Living Planet Report, and the methodology was described in greater detail by Loh *et al.* (2005). It has been included in the discussions of potential indicators of progress towards the 2010 Biodiversity Target since very early in the process. A discussion paper for CBD CoP 7 in 2004 (Jenkins *et al.* 2004) set out many of the issues surrounding the development and use of species trend indicators like the LPI at the national level. Continued consideration by subsequent CBD expert groups and further methodological developments in collaboration with ZSL (see Collen *et al.* in press) led to the incorporation of the LPI in the CBD's 2010 Biodiversity Target framework. Since 2005, WWF and the Zoological Society of London have advanced the development of the LPI method and testing of the application of the LPI as a biodiversity indicator. WWF and the Zoological Society of London have now built the largest vertebrate population time series database in the world. With more data and additional fields in the database, it is now possible to produce a much broader range of robust biodiversity indicators.

Data requirements

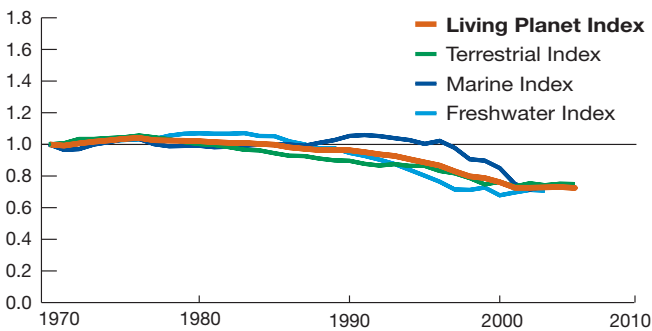


Figure 1: Global Living Planet Index 1970-2005, aggregated by terrestrial, freshwater and marine indices

The LPI is calculated using population time series data for vertebrate species. The species population data used to calculate the index are gathered from a variety of sources published in scientific journals, government reports, wildlife and other natural resource management authorities records, and databases from academic organizations from a variety of projects. Time series are of either population size or a proxy of population size. Some data are total population estimates such as counts of an entire species, others are density measures, for example the number of birds per kilometre of transect. Some data are biomass or stock estimates, particularly for commercial fish species, and others are proxies of population size, such as the number of nests of marine turtle species on specific nesting beaches.

All population time series have a minimum of two data points, and most have many more (mean length is around 20 years, up to 47 years for the longest time series; Collen *et al.* in press), collected by methods that are comparable across years, so that it is possible to determine a trend. A population estimate taken at one point in time would only be used with a second estimate from another survey of the same population at another point in time, if it was clear that the second was comparable with the first.

The index is the geometric mean of three sub-indices relating to the terrestrial, freshwater and marine systems. The data are held in a central LPI Database, which currently holds over 9,500 unique time series records (Table 1). Some of these records are replicates of other time series data, for example there are many time series of bird species from all of North America and also from Canada and the

Table 1: Number of population time series in the LPI database by taxonomic class and system, November 2007

	Terrestrial	Freshwater	Marine	Total
Birds	2,432	948	729	4,109
Mammals	1,191	82	248	1,521
Fishes		494	461	955
Reptiles	39	96	90	225
Amphibians	21	253		274
Total	3,683	1,873	1,528	7,084

United States of America separately, and so not all are included in the global analysis. The replicate records are usually populations from a smaller scale and so would be useful for looking at national or regional trends.

For many species, the database contains multiple time series, and some taxonomic groups have been much more commonly studied than others. Therefore, the database includes far more species of birds than other groups, and reptiles and amphibians are relatively poorly represented (Table 2).

Similarly, the global database contains far more time series data for some biogeographic realms than for others (Table 3) and therefore over-represents well-studied regions. However, data collection is now targeted at data gaps, so that representation is improved over time.

These data are used to calculate the indices for each system, which are then combined to produce an overall global index. In effect, the trend line represents the average change within the entire collection of population samples within the study period, giving equal weight to each species, whether common or rare, and to small and large populations.

Table 2: Number of species in the LPI database by taxonomic class, November 2007

	Number of species
Birds	811
Mammals	302
Fishes	241
Reptiles	40
Amphibians	83
Total	1 477

Table 3: Numbers of species included in the LPI by realm and ocean, November 2007

	Terrestrial	Freshwater	Marine	Total
Australasian	41	16		57
Adrotropical	105	87		192
Indomalayan	41	30		71
Nearctic	394	181		575
Neotropical	71	57		128
Palaearctic	199	119		318
N. Atlantic/Arctic Ocean			185	185
S. Pacific/Indian Ocean			52	52
N. Pacific Ocean			84	84
S. Atlantic/Southern Ocean			48	48
Total	851	490	369	1710

National and regional use

NATIONAL RELEVANCE

A national or regional LPI is potentially of great use at national scale for tracking progress towards the 2010 and other biodiversity targets, and for assessing the long-term effectiveness of sectoral policies aimed at conserving biodiversity. LPI for subsets of species are also relevant to monitoring national progress with respect to the goals of the Ramsar Convention, the Convention on Migratory Species and CITES, as well as other international processes and agreements, such as those addressing forests and marine systems.

It is important to recognize that the LPI method uses and is constrained by data that are available and so interpretation of an index at a national scale must take into account potential biases towards well-known taxonomic groups and well-studied locations. These problems are likely to be of greater magnitude in countries with high biodiversity and highly complex ecosystems such as humid tropical forests or coral reefs, where available data on population trends are usually scarce. It may be difficult to achieve adequate representation of species diversity, though there have been some notable successes, and with adequate data collection, the technique employed in the LPI can be relevant to all areas. Application of current LPI data at the national scale therefore requires an examination of data coverage to test for certain biases, and interpret it accordingly. At the national level it may also be possible to complement existing data with new studies that help to fill gaps.

IMPLEMENTATION

Measuring change in population size is a promising approach for tracking national trends in the abundance of species and this application of the method is currently being advanced and tested using data sets for Canada and Uganda. Three national indices have been produced to date, some of which have been used by WWF regional offices and to varying degrees adopted by governments as official national indicators

To produce a national-scale LPI, a period of targeted data collection is undertaken to supplement the existing data for the target country in the LPI database. This is done using the standard data sources but also by establishing contacts with local organizations and individuals who may have a greater knowledge of data availability and access to unpublished monitoring reports. The analysis of a country-level data set is done using the same method as the global LPI, although the aggregation of the final index may differ according to the composition of data and the need for any weighting.

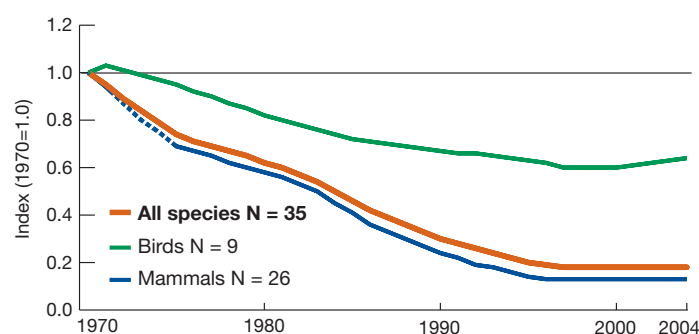
UGANDA

Makerere University in Uganda has been producing 'State of Uganda's biodiversity' reports since 1998 (Pomeroy et al. 2006), using the LPI method to analyse trends and providing a regular input of data into the LPI database. Despite Uganda's recurring political and economic problems over the last four decades, monitoring of at

least some species (mainly large savannah ungulates but also some forest primates and wetland species), has been undertaken since the 1960s. From these admittedly limited data sets, it has been possible to construct a series of indices using the LPI method, persuasively showing the decline in the abundance of certain species in the country's natural ecosystems from 1970 to 2004.

The Living Planet Index for Uganda combines the trends from the species population indices of Uganda's forests, freshwaters and savannahs. The savannah data set is relatively extensive, comprising whole-country estimates for populations of 16 species of large mammal, while the data sets for forests and freshwater are smaller and less comprehensive (five and four species respectively).

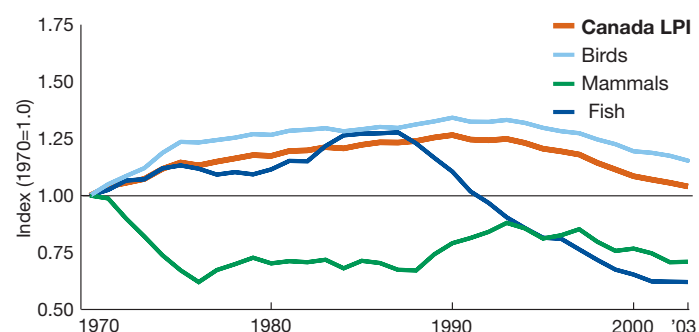
Figure 2: The Living Planet Index for Uganda 1970-2004, showing the disaggregated bird and mammal indices



CANADA

In 2007, WWF-Canada produced the Canadian Living Planet Report which included a national index and disaggregations of the data set relevant for Canada. The report was used as a general communication tool to demonstrate trends in biodiversity and the Ecological Footprint of Canada and gave recommendations to both policy makers and the general public on action for the future.

Figure 3: The Living Planet Index for Canada 1970-2003, showing the disaggregated indices for birds, mammals and fish



REGIONAL

In 2008, WWF combined terrestrial and freshwater species data to provide an indication of biodiversity trends within Europe, North America and Asia-Pacific – the regions with the most data available. Unfortunately, species population data from Latin America and Africa were insufficient to show overall trends for those continents as a whole with confidence, but data availability is improving and it is expected that it will be possible to make indices for these regions by 2010

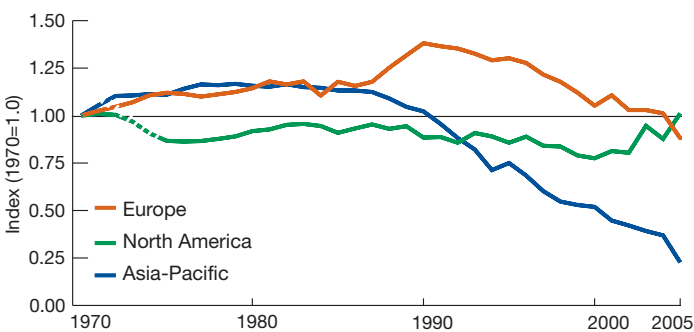


Figure 4: Temperate and tropical freshwater species, 1971-2005, showing combined indices for Europe, North America and Asia-Pacific

The European index shows an initial positive trend and then a decline since 1990, but there has been little absolute change since 1970. The North American index shows no overall trend from 1970 to 2005. The Asia-Pacific region has undergone the greatest industrial and economic change over the last 20 years, and the index for this region displays the greatest decline in species population trends since the late 1980s

DATA

The principal constraint in using LPI approaches at national scale is the availability of enough appropriate population time series data to be representative of the systems of interest within a single country. Unless a comprehensive and structured national monitoring programme has been implemented where appropriate data are available, they are likely to be geographically clustered into well-studied areas and to focus on particular taxa for which there is national expertise and/or interest. Nevertheless, they should provide the starting point for an informative national scale index, which can be built upon.

The data required are estimates of the sizes of individual populations from at least two points in time using comparable methods. These estimates could be for the whole of a national population of a particular species or for individual local populations. The methods used could include direct census and density measures, such as the

number of birds per kilometre of transect. Biomass or stock estimates are also useful, particularly for commercial fish species, in combination with CPUE data. In some cases, proxies for population size, such as surveys of nests or dung, are appropriate measures. The critical point is the comparability of the census methods used at different times.

Potential data sources

The most useful data for calculating LPIs are generated by long-term monitoring programmes. Globally, the greatest monitoring effort is devoted to marine fishes of economic importance and to birds. The bird species that are surveyed regularly by networks of mainly amateur ornithologists are by far the best known large terrestrial group, and a wealth of data in the form of stock estimates for marine fish populations contribute to the majority of marine data sets. Data for other species groups are available though often for fewer series. Efforts are being made to monitor less studied taxa, for example, recently there have been increased efforts to monitor amphibians because of rising concern for the widespread decline and extirpation of local amphibian populations.

Data on population trends are collated primarily from academic research literature in both national and international journals. Other fruitful sources are the records of wildlife and other natural resource management authorities, including those of individual protected areas and long-term forest inventory programmes. In addition, many national-level monitoring schemes are reported through government departments and are available online or in published reports. Many relevant data are unpublished, so dialogue with relevant researchers and authorities is very important for identifying key data sets. This is particularly important when producing a national index where local expertise and network building can be beneficial to the data collection effort.

Sample size and data quality considerations

Sample size is an important consideration when producing a national index and the ideal data set has a large, representative number of populations and species. This is not always achievable, so an understanding of the composition of the data set is essential when interpreting the trends observed. Smaller samples may still be useful if these represent a high proportion of the total number of species in the set being sampled (e.g. the UK farmland birds index is based on only 19 species, but these are a high proportion of the total number of farmland bird species in the UK), or if all the species in the sample show similar trends and therefore the overall trend has low intrinsic variance.

Assessing the quality of data to be included in the index is essential. It is important to ensure that the survey methods and area covered are clearly documented and comparable for each survey of the series. Five data quality measures on the scale, data type, variation and data source are also recorded in the global LPI database for

every population collected, so that the quality of the data set can be assessed. Variation in the data includes looking for outliers that are far removed from the mass of data, and which may be detected when the data is graphed. Outliers should be investigated carefully. Often they contain valuable information about the population under investigation or the data gathering and recording process. Before considering the possible elimination of these points from the data, one should try to understand why they appeared and whether it is likely similar values will continue to appear. Of course, outliers may be bad data points.

In almost all cases there will be a trade-off between data quality and data availability. Too stringent an application of data quality criteria will mean that the number of usable data sets may become vanishingly small. Too relaxed an approach will mean that the indicators produced will be difficult to defend and therefore lose much of their impact.

Calculating the index

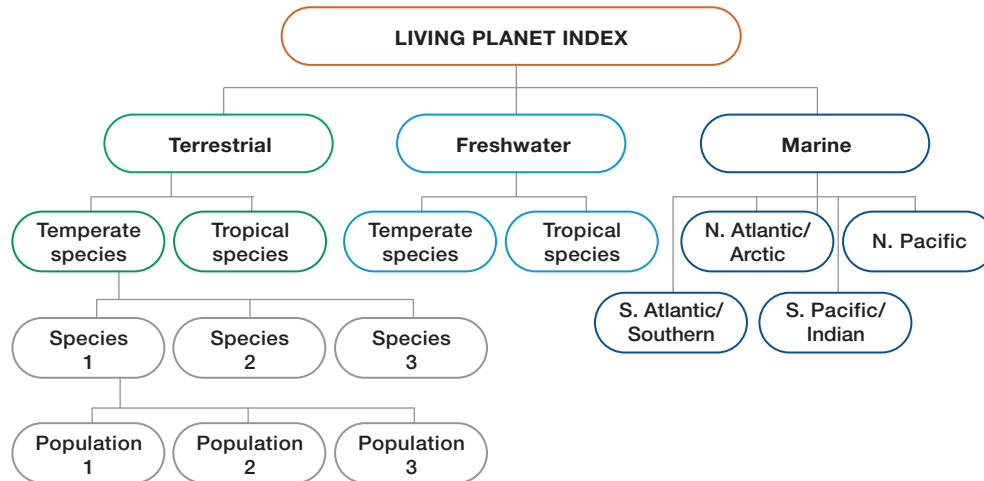


Figure 5: Hierarchy of indices within the Living Planet Index

Before calculating the global LPI, species were first divided according to whether the principal habitat is terrestrial, freshwater or marine and then, because many more population data are available from temperate regions of the world than tropical (whereas species richness is higher in the tropics), species populations were further divided into temperate and tropical groups. Individual indices were calculated for each of the six groups, and these six were then combined to create the global LPI, with each being given equal weight. If the LPI data were not grouped in this way, the index would be dominated by temperate terrestrial species. However, disaggregating and recombining the data in this way is not always necessary when calculating a national-level index. The simplest way to create a national LPI is to calculate an index whereby each species is given equal weight. Alternatively, if there are more data available from one part of the country than another, or from one habitat type than another, then it is possible to disaggregate data and recombine the indices in a way that is appropriate to the national data available.

LPI METHOD

The LPI method described below is taken from Loh *et al.* (2005), as adapted in Collen *et al.* (in press). For each population time series, it necessary to calculate the logarithm of the ratio of population measure for successive years (d) as:

$$1) \quad d_t = \log_{10}(N_t/N_{t-1})$$

where (N) is the population measure and (t) is the year. One per cent of the mean population measure value for the whole time series should be added to all years in time series for which (N) was zero in any year. Missing values can be imputed with log -linear interpolation:

$$2) \quad N_i = N_e \left(N_f / N_e \right)^{[(i-e)/(f-e)]}$$

where (i) is the year for which the value is interpolated, (e) is the preceding year with a measured value, and (f) is the subsequent year with a measured value. For species with more than one population time series, the mean value of (d) should be calculated across all time series for that species:

$$3) \quad \bar{d}_t = \frac{1}{p_t} \sum_{i=1}^{p_t} d_{it}$$

where (p_t) is the number of populations in year (t). Then using species-specific values for (d) the mean is calculated across all species for each year:

$$4) \quad \bar{d}_t = \frac{1}{s_t} \sum_{i=1}^{s_t} d_{it}$$

where (s_t) is the number of species in year (t).

The index value (I) for each year (t) is calculated as:

$$5) \quad I_t = I_{t-1} 10^{\bar{d}_t}$$

and

$$6) \quad I_0 = 1.00$$

The LPI is usually set to 1 in 1970 but any year may be chosen, according to the available data.

An alternative method of deriving values for (d) and interpolating annual data points is to use a generalized additive modeling technique (Fewster *et al.*, 2000; Buckland *et al.*, 2005). As a general rule, (d_i) should be calculated using equations (1) and (2) above for all time series with n<6. For all other time series, it is possible to

implement a generalized additive model (GAM). Generalized additive modelling is used to determine the underlying trend in each population time series, where time series are of sufficient length. These are then used to calculate the average rate of change in each year across all species. (Collen, *et al.*, in press), using the following:

- 1 Fit a GAM on observed values with $\log_{10}(N_i)$ as the dependent variable and year (t) as the independent;
- 2 Set the smoothing parameter to the length of the population time series divided by 2;
- 3 elect the smoothing-parameter value by comparing the estimated degrees of freedom when the smoothing parameter was successively incremented by 1;
- 4 Use fitted GAM values to calculate predicted values for all years (including those with no real count data); and
- 5 Average and aggregate (d) values from the imputed counts as described above.

A GAM framework might be advantageous in long-term trend analysis because it allows change in mean abundance to follow any smooth curve, not just a linear. The GAM method has greater flexibility for drawing out the long-term nonlinear trends that are generally not elicited in the discrete annual estimates of the other method.

The global index is calculated according to the hierarchy in Figure 5; the initial index value is for 1970 and is set to the value of 1. Confidence limits around index values and switch points highlighting significant changes in the index are generated using a bootstrap resampling technique. These techniques are fully described in Loh *et al.* (2005) and Collen *et al.* (in press).

For further information and guidance, please contact the Living Planet Index Consortium:
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Presentation and interpretation

PRESENTATION

A great strength of the LPI is that it can be presented as an easily understandable trend line analogous to such commonly used economic indicators as GDP or stock market performance indices (see Figure 1).

Disaggregation

For most purposes, the LPI is more informative if broken down into the component indices that relate to particular biomes or systems and/or to particular regions and taxa. This makes it possible to interpret trends and changes in the trends in relation to other indicators, such as change in ecosystem extent, and/or to changes in policy and/or practice.

It is possible to assess error or uncertainty in calculating the index (see Loh *et al.* 2005), and including such information in the presentation can increase credibility, but may also make interpretation more challenging (Figure 6).

Narratives (and relation to other indicators)

Presentation of national or regional scale LPIs should be part of a wider narrative examining trends in biodiversity according to several different measures. Species population trends should be discussed in the context of changes in extent of ecosystems and habitats and, where appropriate, changes in conservation status or extinction risk (RLI – IUCN Red List Index). Where particular groups show distinct trends (for example, Wild Bird Index) the relationship between these and the more generalized index should be discussed. They should also be accompanied by analysis of which taxa have shown the greatest change overall.

MEANING AND CAUSES OF TRENDS

It is important to present results with sufficient contextual information to enable users to interpret them. This may come from other biodiversity indicators, such as trends in the extent of different ecosystem types, or be made part of the narrative surrounding the indicator. For example, the steep global decline in populations of freshwater species has been connected with both increasing levels of

eutrophication and pollution and lack of policy attention to the health of freshwater ecosystems during the 1970s-1990s.

It is also important to recognize that the intervals between censuses may mean that the trends observed are responses to changes that occurred some time previously. Similarly, lag in biological responses may mean that population trend indices only show these after significant delay. Therefore, interpretation needs to take account of changes that may have happened sometime before the calculation of the index.

It is also necessary to consider the sensitivity of the index and to assess if it includes an appropriate number of species to make it a robust reflection of overall biodiversity trends. The index may not be sensitive to changes in species that have particular national importance, for example, for cultural or economic reasons. Further, strong changes in a few very sensitive species may be masked by the trends in a larger number of less responsive species. Therefore examination of component trends should be a key part of putting together and interpreting the index.

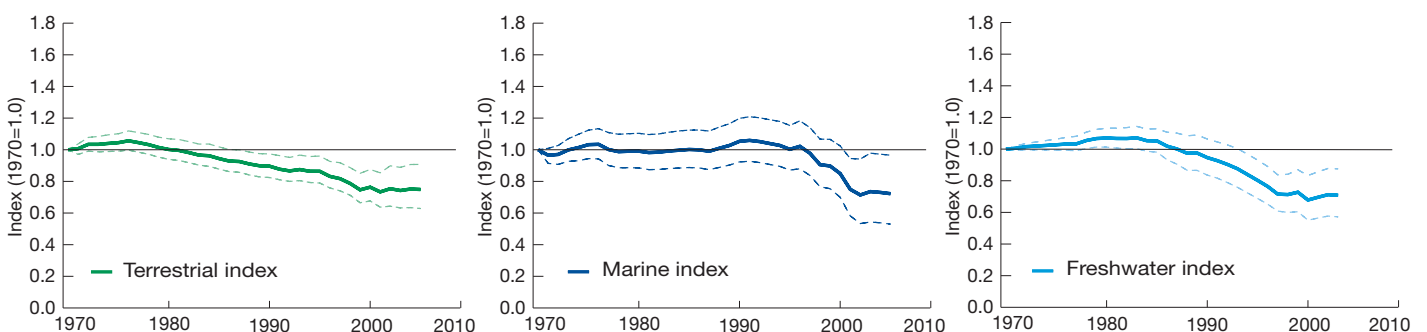
IMPLICATIONS FOR POLICY AND MANAGEMENT

Species trend indices like the LPI provide both a general indication of how effectively policies are reducing the loss of biodiversity – a slower decline in the LPI indicates a likely reduction in the rate of loss of biodiversity – and, in disaggregated form, show more specifically where additional policy or practical intervention may need to be targeted. They also help to illustrate the biodiversity implications of other indicators such as trends in ecosystem extent.

LIMITATIONS

As for other indicators, the trends shown by an LPI are only as good as the data that go into them. They may be affected by changes in census procedure that are not fully documented or other gaps in comparability that have not been detected. As noted above, the index trends may mask important trends in individual populations or particular groups of species.

Figure 6: Terrestrial, marine and freshwater indices, showing overall trends since 1970 with 95 per cent confidence intervals



Good practice

- **Collaboration and engagement/building support and sustainability**

It is important to engage fully with communities of scientists and other experts that may both have relevant data sets and be able to provide guidance on their limitations and appropriate use. Some of these will be academic researchers outside the country, who may be able to help with repatriation of relevant data. It will also be important to engage with amateur networks, which may be sources of important data and can be encouraged through such engagement to ensure that their methods are consistent and provide usable trend data.

- **Data quality standards**

To assess the quality of data included in the index, it is important to ensure that the survey methods and area covered are clearly documented and comparable for each survey of the population time series. Therefore, estimates for the same population from different workers or research teams may not be comparable unless specific efforts have been made to ensure this.

- **Metadata and database design**

It is vital to document thoroughly the species included, the sampling dates and methods and any taxonomic adjustments or interpolation method used. The design of a database to support calculation of an LPI will determine its suitability for data analysis. WWF and ZSL of the global LPI consortium are developing internet access to its global population trend database, and request that any national LPI databases are designed to be compatible with the global database. This will allow any national or regional databases to be enriched with any relevant data from the global database and vice versa, subject to appropriate agreements on use of data. Jonathan Baillie and Ben Collen of the global LPI consortium are keen to provide advice and collaboration for the design of national and regional LPI databases and calculation of the index, and can be contacted at:

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- **Methodological documentation and consistency (cross-calibration)**

It is critical to ensure that the criteria used to assess comparability between population assessments are clear and applied consistently. It is further important to ensure that aggregation from population to species level and then to the wider indices is done consistently.

- **Frequency of updating**

The primary constraint on updating and LPI is the availability and updating of appropriate population trend data.

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