



Living Planet Report 2018

Technical Supplement: Living Planet Index

Prepared by the Zoological Society of London

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The Living Planet Index at a glance

What is the Living Planet Index?

The LPI is one of a suite of global indicators used to monitor progress towards the Aichi biodiversity targets agreed by the Convention on Biological Diversity's (CBD) in 2010. These Aichi Targets require nations to take effective and urgent action to halt the loss of biodiversity and ensure that ecosystems are resilient and continue to provide essential service, thereby securing the planet's variety of life, and contributing to human well-being and poverty eradication.

The LPI tracks trends in abundance of a large number of populations of vertebrate species in much the same way that a stock market index tracks the value of a set of shares or a retail price index tracks the cost of a basket of consumer goods. The data used in constructing the index are time-series of either population size, density (population size per unit area), abundance (number of individuals per sample) or a proxy of abundance (e.g. the number of nests or breeding pairs recorded may be used instead of a direct population count). The Living Planet Index is currently based on time-series data for 16,704 populations of 4,005 species of mammal, bird, reptile, amphibian and fish from around the globe. Using a method developed by ZSL and WWF, these species population trends are aggregated and weighted to produce the different Living Planet Indices.

What subsets of the global LPI are included in the 2018 Living Planet Report?

In addition to the global LPI, the 2018 report contains LPI subsets to reflect trends in:

A) *Biogeographic realms – Afrotropical, Neotropical, Palearctic, Nearctic and Indo-Pacific*

Biogeographic realms combine geographic regions with the historic and evolutionary distribution patterns of terrestrial plants and animals. They represent large areas of the Earth's surface separated by major barriers to plant and animal migration – such as oceans, broad deserts and high mountain ranges – where terrestrial and freshwater species have evolved in relative isolation over long periods of time.

B) *Freshwater*

Each population is assigned to one system – terrestrial, freshwater or marine. This is mostly dependent on where the population is located, rather than where the species lives in general, so species which are found in more than one system, such as Pacific salmon, will be assigned to marine if monitored in the ocean and freshwater if monitored in a river (the latter is usually the case). The freshwater LPI consist of birds, mammals, amphibians, reptiles and fish monitored in freshwater habitats such as rivers and wetlands.

What are the main trends shown by the LPI?

The main result from this Living Planet Report is that globally, monitored populations of birds, mammals, fish, reptiles and amphibians have declined in abundance by 60% on average between 1970 and 2014. The results indicate that species are faring much worse in freshwater systems and in tropical realms. Freshwater populations declined by an average of 83%, while realms declined by between 23% and 89% (Table 1).

Table 1: Trends in the Living Planet indices between 1970 and 2014, with 95% confidence limits. Positive numbers indicate an increase, negative numbers indicate a decline (WWF, ZSL, 2018). Please note that a species may be monitored in multiple realms and systems, and that realm and system totals may be greater than the global total.

		Number of species	Per cent change 1970 - 2014	95% confidence limits	
				Lower	Upper
Global	Global	4,005	-60%	-67%	-50%
Systems	Freshwater	880	-83%	-90%	-73%
Biogeographic realms	Nearctic	875	-23%	-47%	+11%
	Neotropical	689	-89%	-94%	-72%
	Palaearctic	576	-31%	-50%	-6%
	Afrotropical	320	-56%	-73%	-27%
	Indo-Pacific	488	-64%	-82%	-30%

Interpreting the results

Does the trend in the global LPI mean we have lost 60% of all animals?

Although the LPI uses time-series of either population size, density, abundance or a proxy of abundance, the overall trend calculated represents an average trend in population change and not an average of total numbers of individual animals or species lost. Figure 1 explains this difference using three example populations of three different species, all of which declined but by different percentages. The tables show that although the average percentage change is 60%, the total number of animals in the three combined populations has not declined by this much.

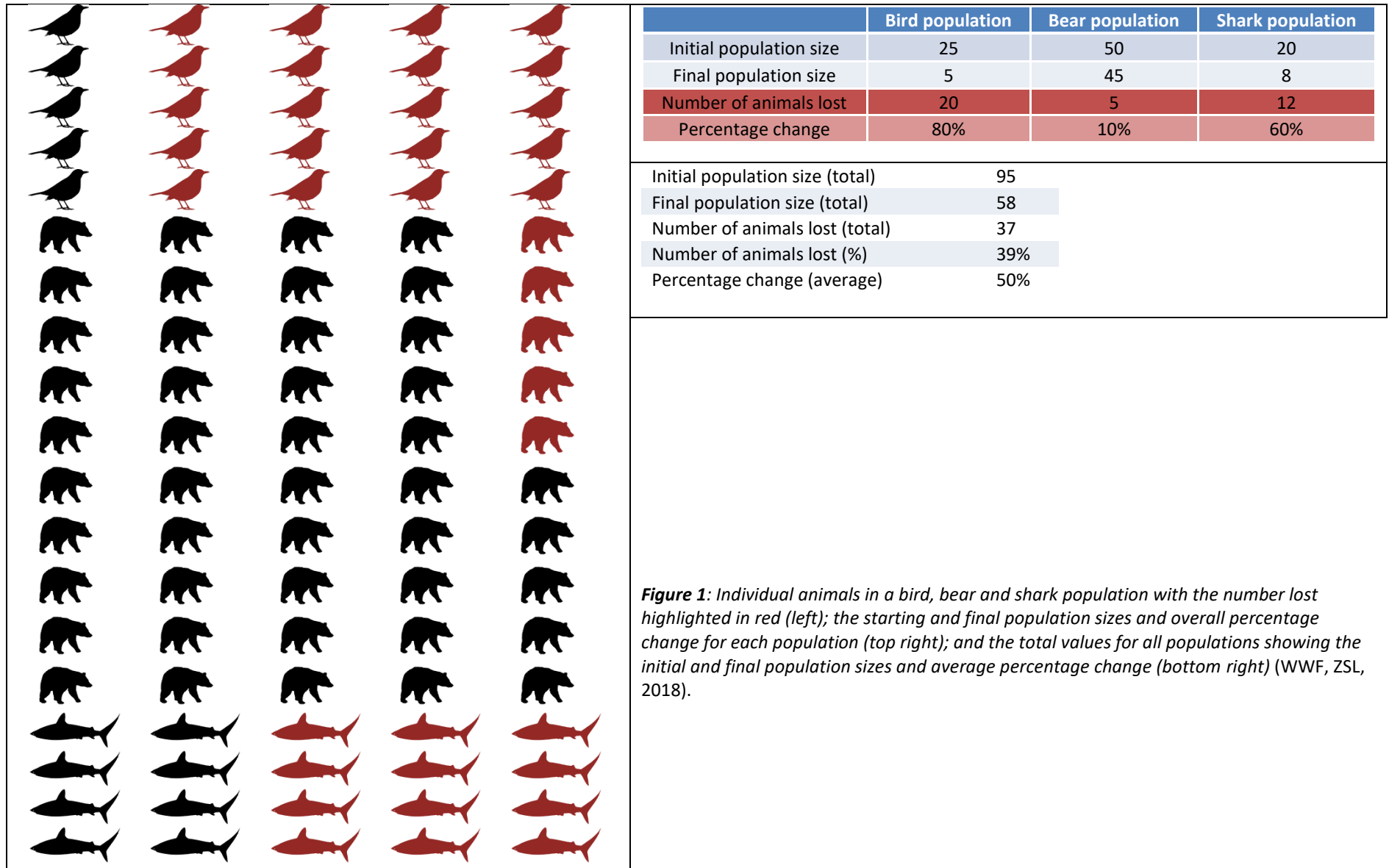


Figure 1: Individual animals in a bird, bear and shark population with the number lost highlighted in red (left); the starting and final population sizes and overall percentage change for each population (top right); and the total values for all populations showing the initial and final population sizes and average percentage change (bottom right) (WWF, ZSL, 2018).

What does the LPI indicate?

LPI results are calculations of average trends. This means that for the global LPI some populations and species are faring worse than a 60% decline whereas others are not declining as much or are increasing. The average trend calculated for each species in the LPI shows that just over half of reptile, bird and mammal species are stable or increasing (Figure 2). Conversely, the average trend for over 50% of fishes and amphibians species shows a decline.

As the number of species which have positive and negative trends are more or less equal, this means that the magnitude of the declining trends exceeds that of the increasing trends in order to result in an average decline for the global LPI. This also suggests that the global LPI is not being driven by just a few very threatened species, but that there are a large number of species in each group (almost 50%) that together produce an average declining trend.

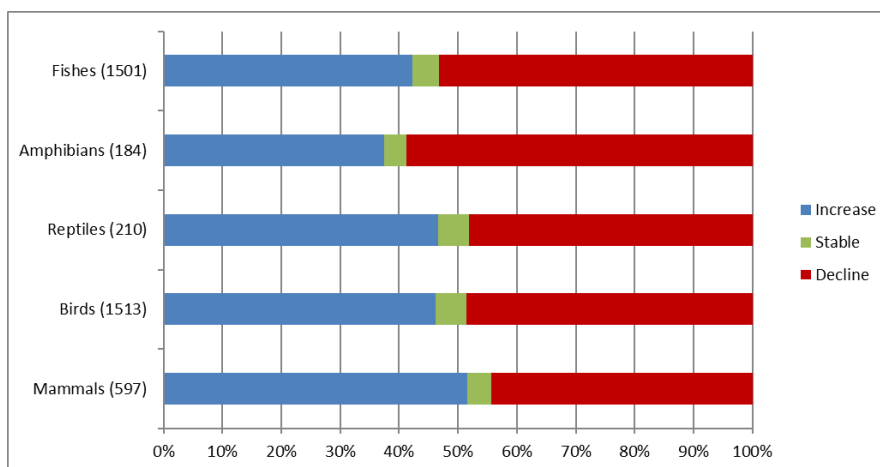


Figure 2: The proportion of species in each taxonomic group where the average trend is an increase, stable or a decline (WWF, ZSL, 2018).

Why do percentages reported for LPIs change from year to year?

The global and realm LPIs show a declining trend as also seen in the 2016 and 2014 editions of the *Living Planet Report*. However, the magnitude of the trend is different than in previous years for many LPIs. The reason for this is that the dataset is continually evolving and for each *Living Planet Report* a larger dataset is available for analysis. Data for the Living Planet Index are gathered from a variety of sources such as journals, online databases and government reports that contain time-series of vertebrate populations spanning any number of years between 1970 and 2014. A different composition of species and populations means that the average value of each LPI can change. Some of these new populations and species will add more information to more recent years, so that indices can be extended by two years, as is usually the case with each instalment of the report. The new percentages stay within the same range (as measured by the confidence limits) as previous results so there are similar overall trends even if the final percentage value is often different.

What does the LPI tell us and what does it not?

The LPI tracks trends in abundance of 16,704 monitored populations of 4,005 vertebrate species. It is not a census of all wildlife but reports how wildlife populations have changed in size – as opposed to the specific number of animals that have been lost or gained (see also ‘Does the trend in the global LPI mean we have lost 60% of all animals?’). A list of what the LPI is and isn’t is compiled in Table 2.

Table 2: *What does the LPI tell us and what does it not? (WWF, ZSL, 2018)*

What the LPI is	What the LPI isn't
An indicator of population trends	An indicator of species extinctions
An indicator that communicates population trends for species with backbones (vertebrates)	An indicator of all biodiversity, including plants and invertebrates
A species indicator based solely on available, verifiable data	An indicator of all species in all locations globally
A continually updated indicator; the index can change with each new species or population that is added	A static indicator which changes only when data from additional years are incorporated into the database
An indicator of past population change. Also, by extrapolating from the past, the LPI can also be used to predict future values.	An indicator of future population change (although it can be used to predict trends)

The LPI database

How many species and populations are there in the LPI?

The Living Planet Database currently contains over 21,000 populations of over 4,200 species from around the globe. The global LPI is based on 16,704 of these populations, focusing on 4,005 species of mammals, birds, reptiles, amphibians and fish.

Since the last edition of the *Living Planet Report* in 2016 the size of the dataset has increased by 18% in terms of populations, and 8% in terms of species (Figure 3). These changes have also improved the spread of the data among different regions and different taxa (Table 3). In terms of species, the biggest change is seen in fishes and mammals since LPR 2016 (9-10%), and the Neotropical and Afrotropical realms since LPR 2014 (21-26%). The majority of populations have been added to fishes (39% more compared to LPR 2016) and the Nearctic realm, which has 50% more populations than for LPR 2014.

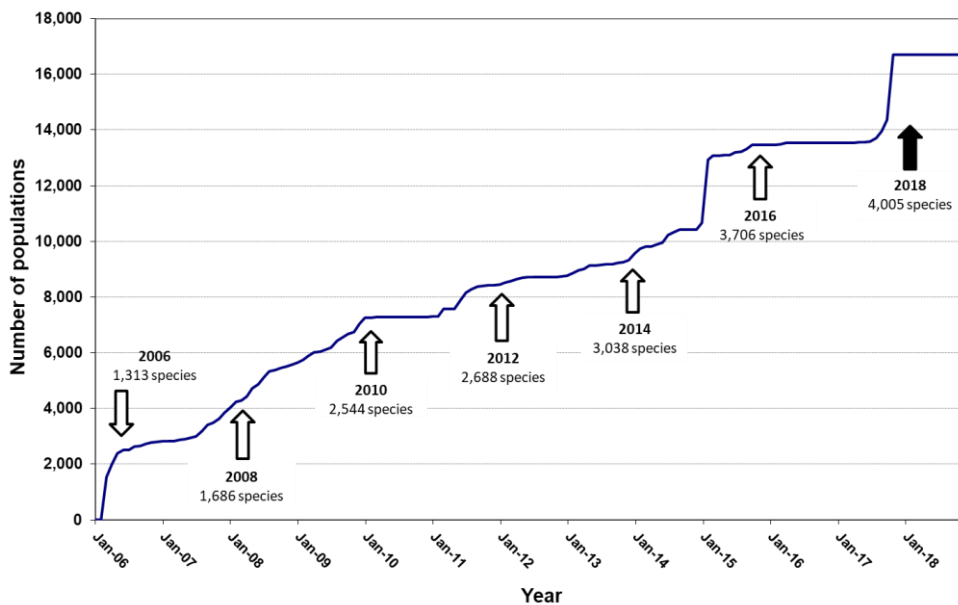


Figure 31: The cumulative number of population time-series in the LPI database and number of species in each Living Planet Report since 2006 (WWF, ZSL, 2018).

Table 3: Changes in the number of populations and species for different taxonomic groups between LPR 2016 and 2018, and for different biogeographic realms between LPR 2014 and 2018. Please note that differences can be negative if populations are excluded or replaced (WWF, ZSL, 2018).

Taxonomic group	2016		2018		Difference	
	Populations	Species	Populations	Species	Populations	Species
Birds	5,314	1,415	5,433	1,513	2%	7%
Mammals	2,572	550	2,894	597	13%	9%
Fishes	5,275	1,369	7,329	1,501	39%	10%
Reptiles and amphibians	991	372	1,048	394	6%	6%
Realm	2014		2018		Difference	
	Populations	Species	Populations	Species	Populations	Species
Nearctic	1,607	745	2,417	875	50%	17%
Neotropical	762	548	1,040	689	36%	26%
Palaearctic	2,892	541	2,866	576	-1%	6%
Afrotropical	1,018	264	1,115	320	10%	21%
Indo-Pacific	969	423	1,083	488	12%	15%

Where do the data used in the LPI come from?

Across the globe, wild animals are counted for a variety of different reasons. If such monitoring is done over multiple years in a particular area, the change in population sizes can be used to establish whether, on average, the abundance of monitored species has increased, decreased or stayed the same. This abundance change information is taken from the Living Planet Database, which comprises time-series of either population size, density, abundance or a proxy of abundance of any vertebrate species in any location. Data can be included only if a measure of population size is available for at least two years, information is available on how the data were collected, what the units of measurement were, and the geographic location of the population. The data must be collected using the same method on the same population throughout the time-series and the data source referenced and traceable. Time-series information for the LPI is currently collated from over 2,800 individual data sources such as published scientific literature, online databases and grey literature.

While an LPI can be calculated using data from any species, the current approach focuses only on vertebrate species (i.e. birds, mammals, fish, amphibians and reptiles) because these are groups that have been monitored more consistently and for longer.

How is information on threats to LPI populations collected?

Alongside the population data, information on threats to a population is recorded in the database and this is used to produce the summary statistics shown in the report. Up to three threats are recorded for each population according to information from the data source. These threats are then ranked as primary, secondary and tertiary, although this ranking is not taken into account when threat type frequency is examined. Threat data are not always available, in which case the population is given an 'Unknown' threat category. These are not included in the summary statistics.

Are extinct species included in the LPI?

Yes, although there are very few. For example, the Golden toad (*Incilius periglenes*) is listed as Extinct on the IUCN Red List of Threatened Species, as extensive searches have not managed to locate any individuals of this species since 1989. In the LPI, the last recorded survey data is included, which documents the decline of this species (Crump et al., 1992). If some individuals of a species are alive only in captivity, then a species is assessed as Extinct in the Wild on the Red List. This is the case for the Guam rail (*Hypotaenidia owstoni*), for which there is also data in the LPI. This species declined because of predation from an introduced Brown tree-snake on the island of Guam. A captive population of the Guam rail exists in a snake proof enclosure on the island.

Calculating the LPI

How is the LPI calculated?

The global LPI is calculated based on 16,704 population time-series of 4,005 species which are gathered from a variety of sources. For each population, the rate of change from one year to the next is calculated. If the data available are from only a few, non-consecutive years, a constant annual rate of change in the population is assumed between each data year. Where data are available from many years (consecutive or not) a curve is plotted through the data points using a statistical method called generalized additive modelling. Average annual rates of change in populations of the same species are aggregated to the species level and then higher levels (Collen et al., 2009). The higher-level aggregation is based on a weighting system that takes into account species richness to address certain geographic and taxonomic biases in the LPI data set (McRae et al., 2017). This weighted approach is described in more detail below.

Why does the LPI use a weighted approach?

The LPI contains data for 4,005 out of an estimated 62,839 vertebrate species that have been described globally. There is no “perfect LPI” which has data for all species from all over the world. The challenge therefore is to represent all 62,839 described species using those for which data are available. One way to address this problem is to collect more data and improve the taxonomic and geographic coverage of the dataset. This is the approach taken until LPR 2012.

A second approach is to make the indicator more representative of vertebrate biodiversity by accounting for the estimated diversity of species globally. Because the LPI dataset is not uniformly distributed across regions and species (Figure 4), a new approach is being employed to calculate indices that reflect the number and distribution of vertebrate species in the world. The LPI-D method (McRae et al., 2017) involves a system of weighting that reflects the actual proportions of species found in each taxonomic group and realm. These proportions allow the index to be weighted accordingly and are presented below.

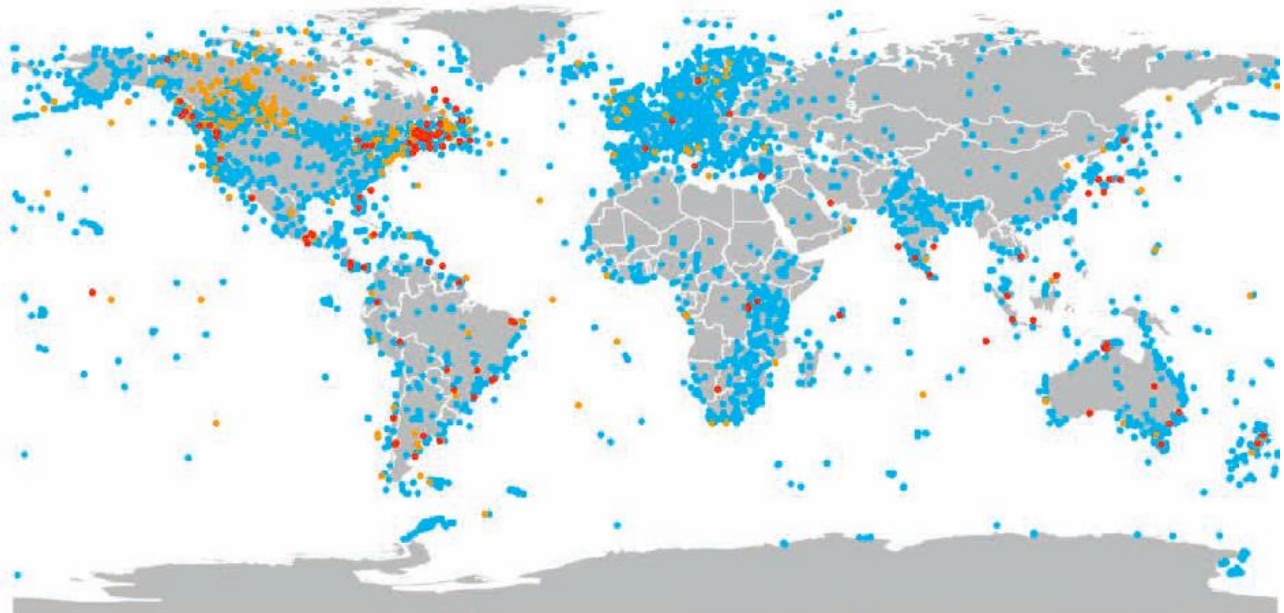


Figure 4: Map showing the locations of the monitored populations in the LPI. Newly added populations since the last report are highlighted in orange, or in red for species new to the LPI (WWF, ZSL, 2018).

How do the LPI weightings work?

The higher-level aggregation in the LPI is based on a weighting system that takes into account species richness to account for certain geographic and taxonomic biases in the data set (McRae et al., 2017). Table 4 shows the proportion by realm of the total number of species found in each taxonomic group. The greater the number for a given group, the more weight given to the population trends of those species. For example, fish species represent the largest proportion of vertebrate species in both freshwater and marine biogeographic realms, so this group is given most weight in the index calculation for each realm. In the terrestrial realms, reptiles and amphibians are the largest vertebrate group in the tropical realms (Afrotropical, Neotropical, Indo-Pacific), whereas birds are the largest group in the temperate realms (Nearctic, Palearctic).

Table 4: The proportion of species by group and realm for (a) terrestrial, (b) freshwater and (c) marine species. Species estimates taken from Wildfinder (WWF, 2006), IUCN Red List (IUCN, 2013), Freshwater Species of the World (WWF/TNC, 2013) and the Ocean Biogeographic Information System (OBIS, 2012). The values also represent the weighting applied to the data for each species group when calculating the global and system LPis. Because of low representation in total numbers of species and populations, some groups are combined: individual classes of fish into one fish group, reptiles and amphibians into herpetofauna, and Indo-Malaya, Australasia and Oceania into an Indo-Pacific realm (WWF, ZSL, 2018).

a. Terrestrial realm weightings applied to data:

	Afrotropical	Nearctic	Neotropical	Palearctic	Indo-Pacific
Birds	0.387	0.376	0.388	0.434	0.397
Mammals	0.198	0.250	0.128	0.250	0.172
Reptiles and amphibians	0.415	0.374	0.484	0.317	0.431

b. Freshwater realm weightings applied to data:

	Afrotropical	Nearctic	Neotropical	Palearctic	Indo-Pacific
Birds	0.193	0.204	0.107	0.211	0.177
Mammals	0.009	0.014	0.010	0.016	0.008
Reptiles and amphibians	0.207	0.217	0.298	0.180	0.322
Fishes	0.591	0.565	0.584	0.593	0.493

c. Marine realm weightings applied to data:

	Arctic	Atlantic North Temperate	Atlantic Tropical and Sub-tropical	Pacific North Temperate	Tropical and Sub-tropical Indo-Pacific	South Temperate and Antarctic
Birds	0.205	0.144	0.094	0.090	0.056	0.056
Mammals	0.041	0.021	0.008	0.028	0.006	0.024
Reptiles	0	0.003	0.002	0.001	0.006	0
Fishes	0.754	0.833	0.895	0.880	0.932	0.918

This diversity-weighted ('LPI-D') method provides a means of reducing bias in groups such as temperate birds, which have previously dominated some of the global and regional LPIs. As an example, there are 400 terrestrial Palearctic species in the LPI, of which 67% are birds, 27% are mammals, and 6% are reptiles and amphibians. The unweighted LPI-U method would have weighted each group in these proportions. The LPI-D method reflects the proportion of species that should be found in each group. This gives 43% of the weight to bird species, 32% to reptiles and amphibians and 25% to mammals (Table 4a). In other words, the LPI-D method gives reptiles and amphibians more weight, and birds and mammals less weight, to better reflect the actual diversity of species.

The LPI-D method has been used for the global, freshwater and realm LPIs in this report.

How are different LPIs calculated?

Realm LPIs are calculated using an adjusted approach of the LPI-D method described above which ignores system. Terrestrial and freshwater populations are first combined, and then weighting values applied to each species group as outlined in Table 5 to produce LPIs for the Afrotropical, Nearctic, Neotropical, Palearctic and Indo-Pacific realms.

Table 5: The proportion of species by realm for (a) terrestrial and freshwater species and (b) marine species. The values also represent the weighting applied to the data for each realm when calculating the system LPIs (WWF, ZSL, 2018).

	Afrotropical	Nearctic	Neotropical	Palearctic	Indo-Pacific
Birds	0.260	0.265	0.260	0.296	0.308
Mammals	0.133	0.176	0.086	0.170	0.134
Reptiles and amphibians	0.281	0.270	0.326	0.219	0.340
Fishes	0.326	0.289	0.328	0.316	0.218

System LPIs are calculated by first producing realm indices using the LPI-D method as described above. The system LPIs are then calculated using a weighted average of the realm LPIs for that system. The values for the weighting are equivalent to the proportion of vertebrate species each realm contains compared to the estimated total number of vertebrate species for that system (Table 6). For example, the Neotropics carry the most weight and the Nearctic the least in the terrestrial and freshwater LPIs; the Tropical and subtropical Indo-Pacific is the realm given the most weight in the marine LPI.

The global LPI is an average of the terrestrial, freshwater and marine LPIs, giving an equal weight to each.

Table 6: The proportion of species by realm for (a) terrestrial and freshwater species and (b) marine species. The values also represent the weighting applied to the data for each realm when calculating the system LPIs (WWF, ZSL, 2018).

a. Terrestrial and freshwater realm weightings applied to data:

	Afrotropical	Nearctic	Neotropical	Palearctic	Indo-Pacific
Terrestrial LPI	0.190	0.062	0.321	0.116	0.292
Freshwater LPI	0.212	0.061	0.366	0.123	0.226

b. Marine realm weightings applied to data:

	Arctic	Atlantic North Temperate	Atlantic Tropical and Sub-tropical	Pacific North Temperate	Tropical and Sub-tropical Indo Pacific	South Temperate and Antarctic
Marine LPI	0.016	0.146	0.215	0.068	0.457	0.100

A deeper dive: A step-by-step guide to calculating an LPI

An LPI is calculated in multiple steps:

First, each population's size is modelled over time and the population size in any year compared to the population size in the previous year.

The original abundance values are logged, so that differences between years describe a relative rather than an absolute change. This means that we can combine information from populations with different measures of abundance and different numbers of individuals.

In each year, these interannual change values are averaged across all populations of a species to give an overall trend for that species.

The species trends are then averaged to obtain an overall trend.

A type of average known as the geometric mean is used, which has been shown to be particularly suitable for assessing relative change in population sizes (Buckland et al. 2011, Santini et al. 2017).

In cases where the amount of data is large enough, for example for the global LPI, the averaging process is adjusted to account for the fact that species and monitoring programmes are not evenly distributed across the globe. The LPI method then takes into account how much of the world's vertebrate biodiversity the species in the LPI represent by giving most weight within a biogeographic realm to the most species-rich group (McRae et al., 2017). This means that not all of the weight is placed on the groups for which there is more information in the database (although this could be the case in well-monitored areas).

For most realms, fish are given the most weight (around a third), followed by reptiles and amphibians (around a third) and birds (around a quarter), and finally mammals (less than a fifth).

Each realm is then given a weighting depending on its species richness to give an overall trend for this realm.

The averaging and weighting is done separately for populations occurring in the three systems (terrestrial, freshwater and marine), which are then equally weighted to obtain one set of interannual change values.

These values are then turned into the global index by setting the value to 1 in 1970 and relating each change to this baseline.

Confidence limits are calculated around these values which describe how certain we are about the index value in any given year relative to 1970.

The baseline year and the cut-off year are chosen because not enough information is available before 1970 or after 2014 to produce a robust and meaningful index.

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