

Supplementary information: Past, present, and future of the Living Planet Index

Sophie E H Ledger^{1*}, Jonathan Loh², Rosamunde Almond³, Monika Böhm⁴, Christopher F Clements⁵, Jessica Currie⁶, Stefanie Deinet¹, Thomas Galewski⁷, Monique Grooten³, Martin Jenkins⁸, Valentina Marconi¹, Brett Painter⁹, Kate Scott-Gatty¹, Lucy Young¹⁰, Michael Hoffmann¹¹, Robin Freeman¹ and Louise McRae^{1*},

¹ Institute of Zoology, Zoological Society of London (ZSL), London, UK

² School of Anthropology and Conservation, University of Kent, Canterbury, UK

³ WWF Netherlands – World Wide Fund for Nature, Zeist, Netherlands

⁴ Global Center for Species Survival, Indianapolis Zoo, Indianapolis, USA

⁵ School of Biological Sciences, University of Bristol, Bristol, UK

⁶ WWF Canada – World Wildlife Fund, Toronto, Canada

⁷ Institut de recherche pour la conservation des zones humides méditerranéennes, Tour du Valat, Arles, France

⁸ Independent researcher, United Kingdom

⁹ Environment and Climate Change Canada (ECCC), Government of Canada, Gatineau, Canada

¹⁰ WWF UK – World Wide Fund for Nature, Cambridge, UK

¹¹ Conservation and Policy, Zoological Society of London (ZSL), London, UK

* *Joint corresponding authors:* sophie.ledger@ioz.ac.uk; louise.mcrae@ioz.ac.uk

The following supplementary materials include the methods for the citation search in academic and grey literature, and metadata coding (Supplementary Methods 1, Supplementary Table 1), the methods for visualising the growth in number of populations and species by region and taxa (Supplementary Methods 2) results of citation search and metadata coding (Supplementary Note 1, Supplementary Figures 1, 2 and 3 and Supplementary Tables 2,3,4 and 5) and the results of the Altmetric data analysis for key LPI papers (Supplementary Note 1, Supplementary Figure 4 and Supplementary Table 6), an infographic of the underlying data within the LPD (Supplementary Figure 5) and summary of the growth in populations and species in the LPD over time (Supplementary Figure 6), a summary of LPD data diagnostics for underrepresented taxa and realms (Supplementary Tables 7 and 8) and a visualisation of the global aggregation LPI method (Supplementary Figure 7). The data that support the findings are available from the corresponding authors upon reasonable request.

1 Supplementary Methods 1

2 Citation search and data collection

3 Three online platforms of scholarly literature were selected for their complementary coverage of both academic and
4 grey literature and to boost representation of non-English language texts which are often neglected from citation
5 search tools ¹; Scopus, Web of Science and Google Scholar (via the academic citation analytical program Publish or
6 Perish). Keywords chosen for the search were kept as the 'Living Planet Index' across all platforms for consistency
7 and the acronym 'LPI' was not included to reduce the number non-target citations. The timeframe for the search was
8 limited to 1998-2020 to coincide with the development of the LPI and to avoid non-target results from literature prior to
9 the LPI's existence. We note that excluding searches for variations of the 'Living Planet Index' in English and other
10 languages will potentially reduce the representation of LPI use at national and subset levels.

- 11 • **Data screening.** The results of the three citation search platforms were combined into a singular database
12 and screened for search return errors, duplicate entries, Living Planet Report publications and incomplete
13 entries, which were removed from further analysis. Publications with authors from the Indicators and
14 Assessments Unit were coded so they could be differentiated from external users in the future.
- 15 • **Language classification and screening.** The language for each entry was classified from International
16 Organization for Standardization (ISO) language codes using the text within the publication title and two
17 formulas within Google Sheets (ISO language detect and Google Translate functions). Language
18 classifications were screened and erroneous allocations (misinterpreting author names, years, abbreviations
19 and Latin) were corrected.

20 Random sample metadata coding

21 To explore patterns in usage and reach in more detail, a random sample of 341 English language texts were coded
22 with metadata such as geographical scale of focus, how the source used the LPI, and source type (See
23 supplementary Table 1). Originally, we aimed to use the excerpt of text which Publish or Perish extracts from each
24 source publication from Google Scholar to categorise the use of the 'Living Planet Index' for that entry. However,
25 these text 'snippets' were limited in character length, not available for every source and would only return the 1st time
26 the search term was used within the source. To evaluate the use of the LPI within a publication it was determined that
27 returning to the source publication would be necessary.

- 28 • **Random sample.** Given time limitations and time taken to access each source publication and interpret the
29 text and code up fields of interest (informed by a time trial of coding 50 random entries) it was determined that
30 a random sample of >320 English language entries would be selected to act as a representative sample for a
31 week's worth of coding.
- 32 • **Coding the sample.** Fields selected to be manually coded from interpreting the source document were
33 categorising the use of the LPI within the document, the type of document, document affiliation, whether the
34 focus of the document was at a global scale or a focal country, whether the document was accessible online,
35 and a notes field. Definitions for LPI use, document type and document affiliation can be found in
36 Supplementary Table A 1. To keep the source document focal country field standardised and to avoid typos, a
37 data validation tool was used with the IPBES country list. The associated IPBES region was then automated
38 using VLOOKUP.
- 39 • **Data screening.** We recorded whether the source document was irretrievable, or the citation had been
40 misattributed by citation search tool error or by author error and removed these entries from analysis.

1 **Supplementary Table 1**

Use of the LPI		Document type		Source affiliation	
Category	Definition	Category	Definition	Category	Definition
Discussed	The LPI is discussed in detail	Journal article	Published in a peer reviewed journal - to include data paper, editorial and review	GOV	Government or State; agency, commission, department, ministry, administration - government controlled or linked organisation
Figures cited	Figures such as percentages for different data cuts, species numbers etc are presented in some detail.	Research outputs	Preprint academic article, Conference papers published in the context of an academic conference or workshop and Doctoral dissertations/Theses	NGO	Non-governmental organisation - independent of government - usually not for profit
Mentioned	The LPI is referred to by name. This can be a very brief mention, e.g., in a list of indicators, or a slightly more detailed one which does not present figures from the LPRs.	Books and book chapters	Books and book chapters	IGO	Intergovernmental organisation/ international organisation - made from sovereign states (referred to as member states), or of other intergovernmental organisations
Method used	The LPI method is applied to other data	Policy statement	Specify which type in Author/Affiliation field	PRI	Private sector - for-profit businesses that are not owned or operated by the government
Data used	Data from the LPD is used but analysed using a different method	Report	Gov report, Stats report, Research report. Important to specify which Author/Affiliation type in that field	RES	Research institutes and centres, university, and academic institutes
Method & data used	The LPI method is applied to data from the LPD	News or Media article	Published online on a news agency website, magazine, or organisations website	MISC	Miscellaneous - make a note about it in the notes field
Not named	Any of the main publications (Loh paper, Collen paper, LPRs) are cited but the LPI is not used by name.	Teaching material	Presentations, syllabus, Guides for Classroom, teacher, lecturer, Non-classroom, documents for education purposes	MULTI	Multidisciplinary - a combination of different sectors as authorship
Does not appear	The LPI/ Living planet Index does not appear in the text - erroneous retrieval from search	Other	Not a research output - could be; Surveys, Letters, Blog posts, Newsletters etc - make a note in the notes field	MEDIA	Journalists, News agencies
Error in use	The LPI is named but the authors are referring to something else -e.g., footprint analysis or LPR				
Irretrievable	Cannot get access to the document to assess LPI use				

2 **Definitions for metadata coding of the citation search results by usage of the LPI, document type and**
 3 **document affiliation**

4

5

Supplementary Methods 2

The methods for deriving Figure 2 Growth in number of populations and species in the Living Planet Database (LPD) by region and taxa

We used the version of the Living Planet Database from 20th April 2022 to summarise the cumulative increase in species and populations in the database among different regions and taxa. For each year between 2006 and 2022 we summed the number of new populations and species that were added to the database in that year and used the geopolitical region and taxonomic class to categorise them. We combined all fish classes (Actinopteri, Coelacanthi, Dipneusti, Elasmobranchii, Holocephali, Myxini, Petromyzonti) into one group “Fishes”. For marine populations that lie outside of an Exclusive Economic Zone, we assigned them to the category of “International Waters”.

Supplementary Note 1

Results of citation search and metadata coding

The Living Planet Index was cited by a total of 2,152 academic and grey literature documents in 32 languages (including English) between 1998-2020 (see Supplementary Table 2 and Supplementary Figure 1).

Of the total 1,805 English language citations, a random sample of 375 entries were coded with metadata (21% of total); of these entries, 34 were excluded (9% of the random sample) due to the source being irretrievable or due to search tool or author error in attribution (see Supplementary Tables 2, 3 and 4), thus leaving a random sample of 341 entries.

Metadata analysis of what aspects of the LPI project are being used, and how, revealed the most common uses were: mentioning the LPI (31%) and citing LPI figures (30%) with the majority of citing documents focused on the global scale (70%) (See Supplementary Tables 3,4 and 5 and Supplementary Figure 2).

Ninety percent of author and document affiliations were classed as research (academic institution or university, see Supplementary Table 4); of the outputs themselves, 52% were within academic journals (see Supplementary Table 5).

Within regional (9%) and single country focussed documents (21%), the distribution by IPBES region was slightly biased towards Europe and Central Asia (36%) and Asia Pacific (26%) but all regions were represented (See Supplementary Figure 3).

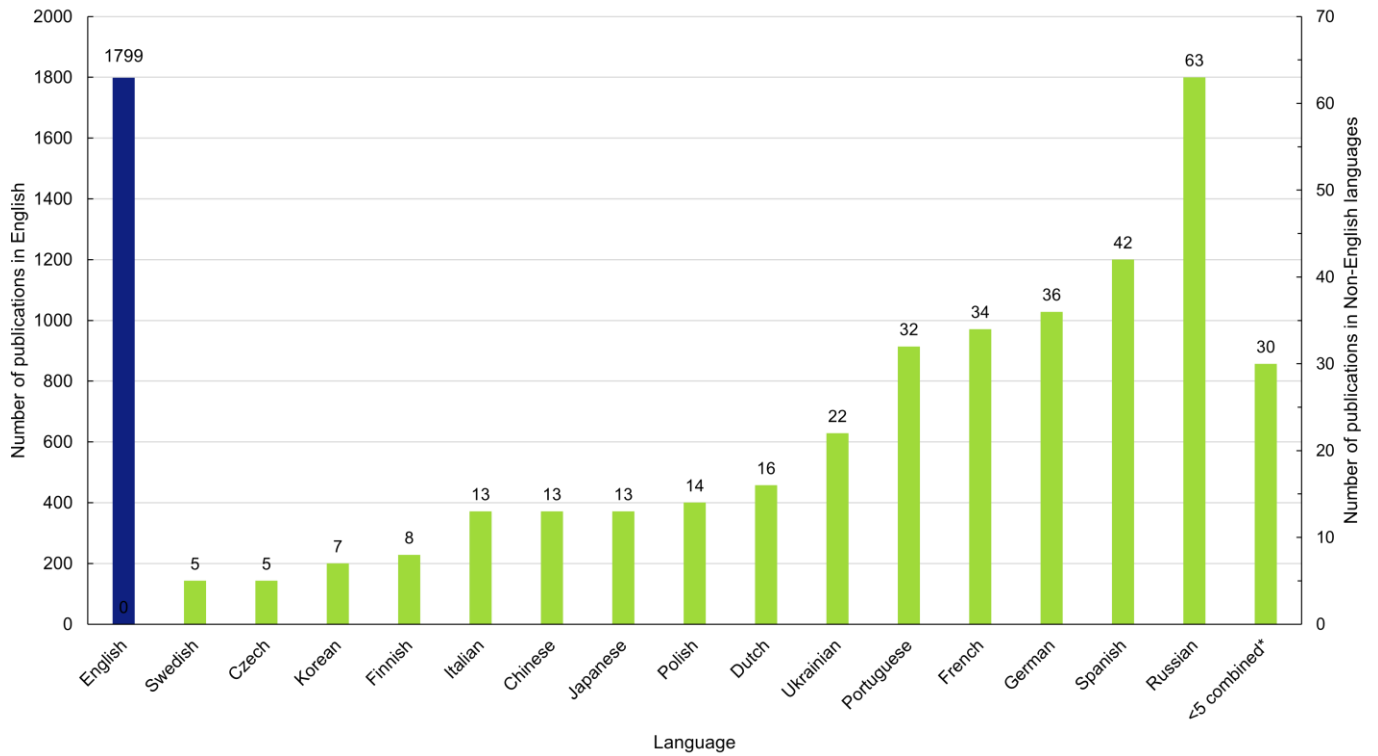
Results of Altmetric data analysis for key LPI papers

As a means of inferring outreach within the scientific community, Altmetric analysis was undertaken on three key academic papers on the LPI method²⁻⁴ and two CBD target reviews which included the LPI^{5,6}; this revealed that these five papers were in the top 5% of all research outputs scored by Altmetric and had high attention scores ≥ 95 percentile (%) compared to outputs of the same age (See Supplementary Table 6 and Figure 4).

Supplementary Table 2 Citation search tool	Number of publications containing the phrase 'Living Planet Index' 1998-2020
Web of Science	46
Google Scholar via Publish or Perish	2,171
Scopus	526
Total unique entries*	2,152
Total random sample of English language entries with complete metadata	375

Results of the citation search for 'Living Planet Index' within literature between 1998-2020. *Unique entries refer those which have been through a data screening and cleaning process to remove duplicate entries, entries pre-1998, entries with no year and entries which contained the “Living Planet Report” in their title.

1 **Supplementary Figure 1**



2
3 **Number of publications citing the Living Planet Index within English (left hand Y-axis) and non-English language (right**
4 **hand Y-axis) texts between 1998-2020.** It is likely that LPI use in non-English languages will have been underestimated despite
5 using the Publish or Perish software. * The following 16 languages had <5 publications; Greek, Catalan, Croatian, Slovenian,
6 Slovak, Lithuanian, Thai, Estonian, Galician, Bosnian, Danish, Romanian, Norwegian, Chinese (Traditional), Hungarian and
7 Indonesian

8 **Supplementary Table 3**

Use of the LPI with document	Number of citations	Percentage %
Mentioned	120	35%
Figures cited	117	34%
Not named	47	14%
Discussed	23	7%
Method & data used	15	4%
Method used	12	4%
Data used	6	2%
Total	341	100%

9 **Results of the coding of how the LPI was being used with a random sample of English-language.**

10

1 **Supplementary Table 4**

Author type or affiliation	Number of citations	Percentage %
Research	306	90%
NGO	10	3%
IGO	10	3%
Governmental	8	2%
Media	4	1%
Private sector	3	1%
Total	341	100%

2 Results of the coding the affiliation of authors and documents which cite the LPI within a random sample of English-
 3 language. Definitions of how the affiliations were classified can be found within in Supplementary materials A Table 1,

4 **Supplementary Table 5**

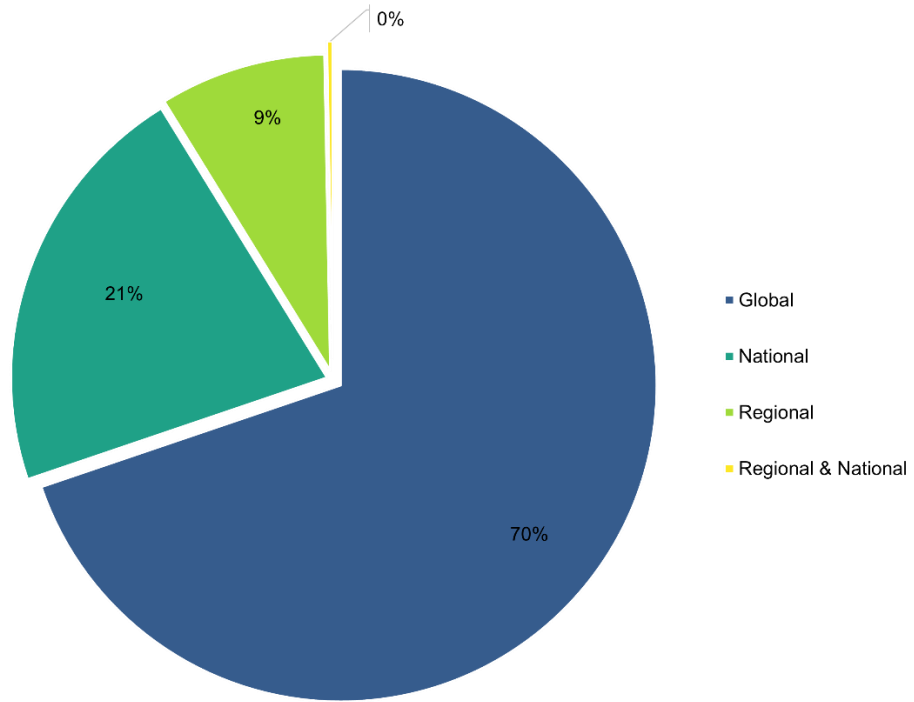
Source	Document type	Number of citations	Percentage %
Academic literature	Journal article	179	52%
	Books and book chapters	69	20%
Grey literature	Research outputs	53	16%
	Report	29	9%
	News or Media article	5	1%
	Teaching material	3	1%
	Other	3	1%
	Total		341

5 Results of the coding the source type and document types which cite the LPI within a random sample of English-
 6 language.

7

1 **Supplementary Figure 2**

2

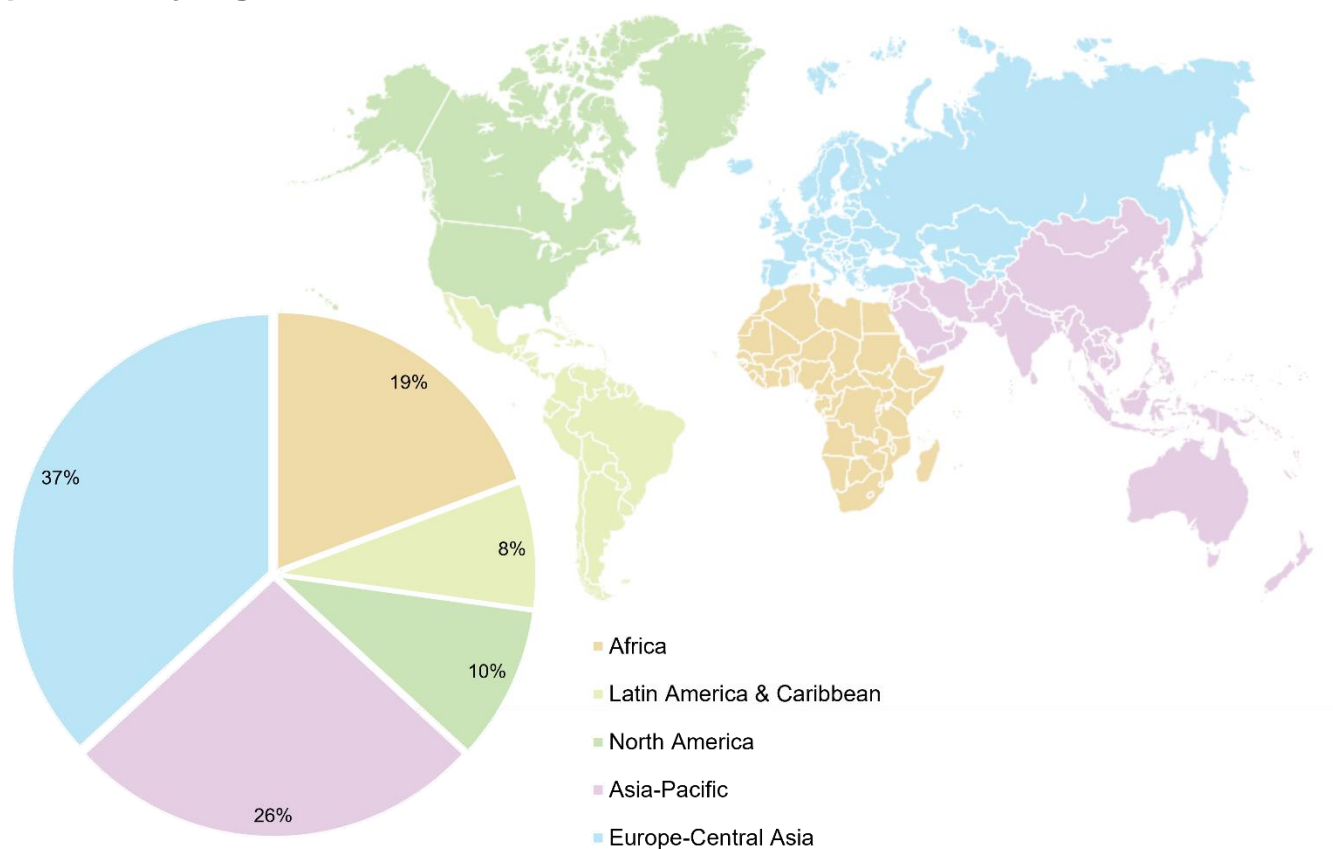


3

4 **Geographical scale of English-language publications which cite Living Planet Index (%).** A random sample of 341 English
5 language publications were categorised as having a Global, National, or Regional scale focus.

6

1 **Supplementary Figure 3**



2

3 **Geographical distribution of national and regional focussed English-language sources which cite the Living Planet Index,**
 4 **by IPBES regions (%).** A random sample of 341 English language sources were categorised as having a Global, National, or
 5 Regional focus; of these 103 entries of National and Regional level sources were identified and attributed to IPBES regions. Within
 6 the national coded data, 37 individual countries were recorded (when counting Wales and England with the UK). Sources marked
 7 as multiple IPBES regions refer to the following: Arctic, Neotropics, Mediterranean and a study that looked at trends in both Canada
 8 and Sub-Saharan Africa. Map adapted from WWF ⁷ and originally sourced from IPBES ⁸.

9

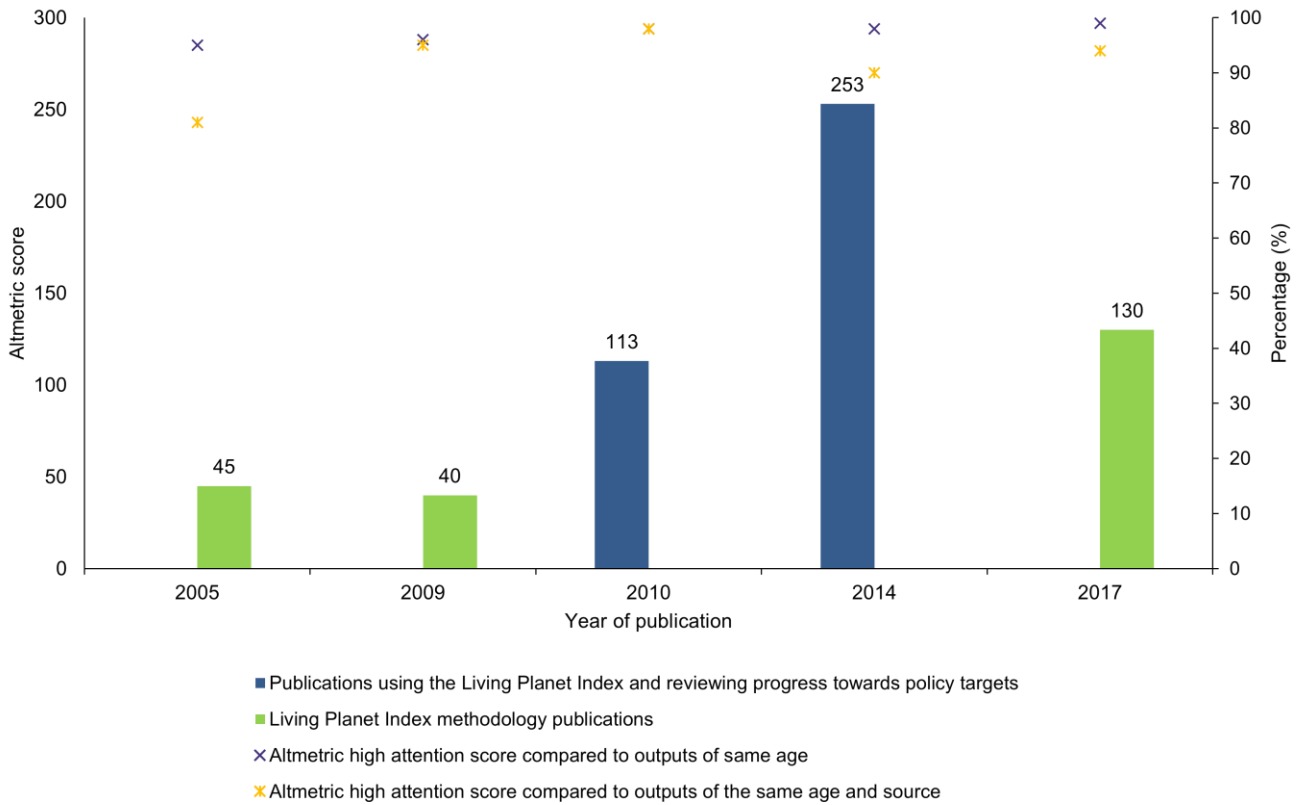
10 **Supplementary Table 6**

Focus	Publication	Attention score	In top percentage of all research outputs scored (%)	High attention score compared to outputs of same age (%)	High attention score compared to outputs of the same age and source (%)
The Living Planet Index method	Loh, J. <i>et al</i> 2005	45	5	95	81
	Collen, B. <i>et al</i> 2009	40	5	96	95
	McRae, L. <i>et al</i> 2017	130	5	99	94
Using the Living Planet Index and reviewing progress towards policy targets	Butchart, S. <i>et al</i> 2010	113	5	98	98
	Tittensor, D. <i>et al</i> 2014	253	5	98	90

11 **Altmetric impact analysis of three key Living Planet Index methodology publications ²⁻⁴ and two policy target review**
 12 **papers ^{5,6}.** Data correct at the time of collection on 19th February 2021.

13

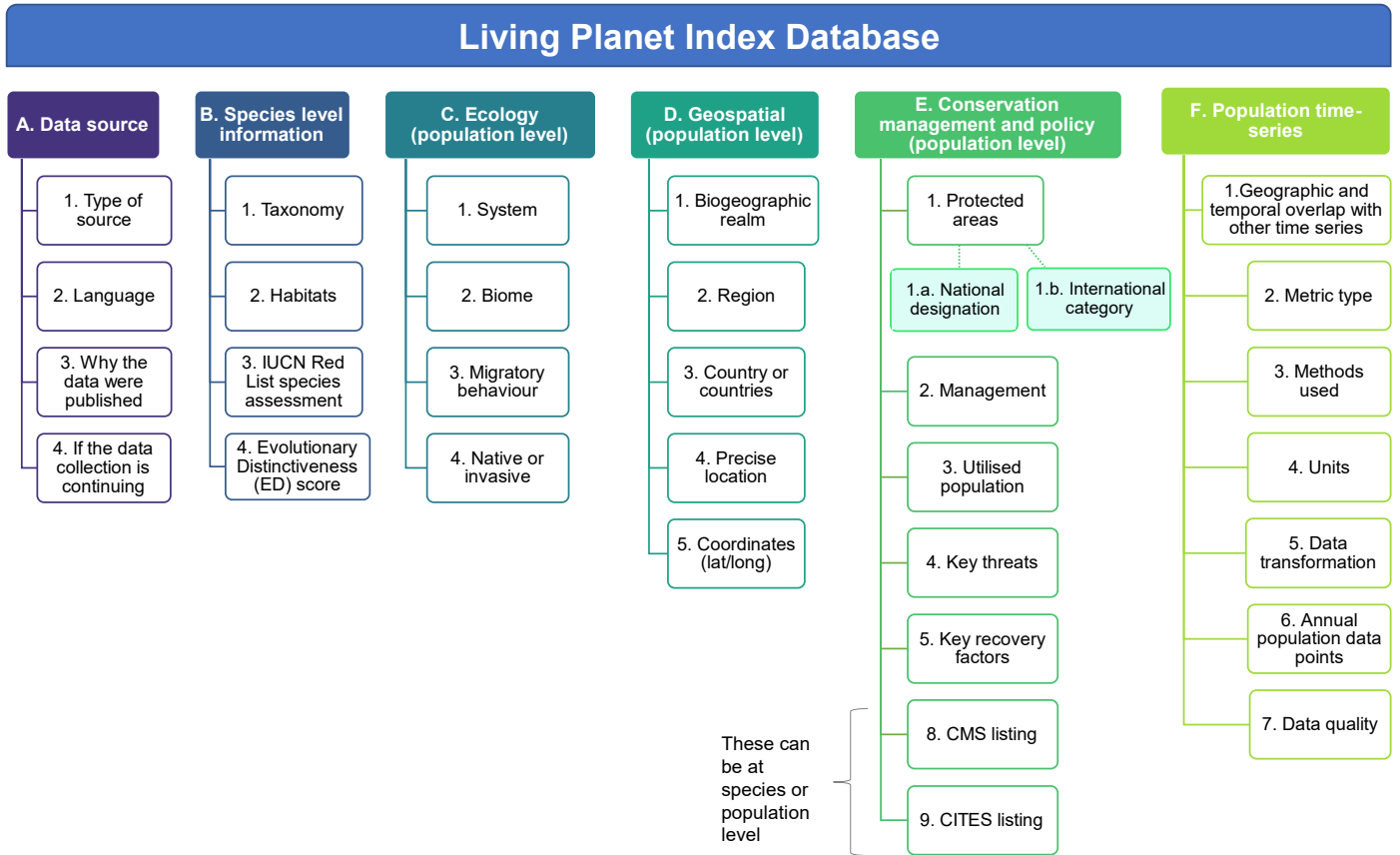
1 Supplementary Figure 4



2

3 **Altimetric scores of the three key Living Planet Index methodology publications²⁻⁴ and two policy target review papers^{5,6}**
4 **on the primary Y-axis.** The percentage of high attention scores compared to outputs of the same age, and same age and source
5 are plotted on the secondary Y-axis. All publications were classed as within the top 5% of all research outputs scored by Altimetric.
6 Data correct at the time of collection on 19th February 2021.

1 **Supplementary Figure 5**



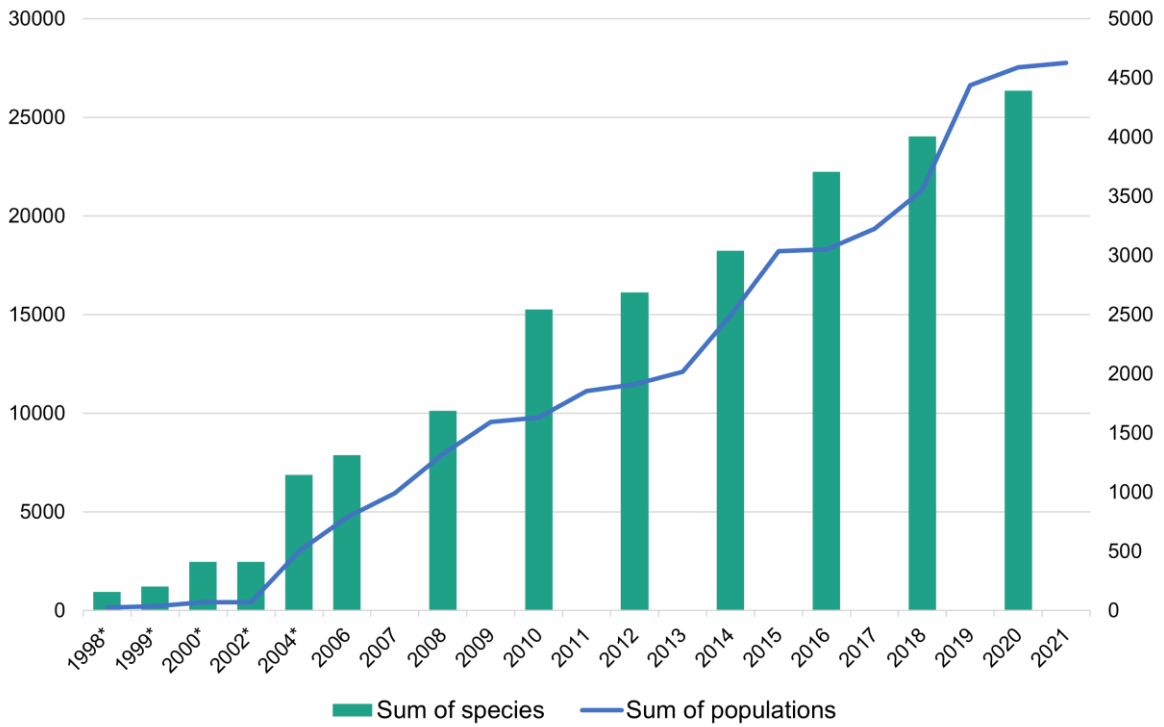
2

3 **A visualisation of the underlying data within the Living Planet Index Database.**

4 The data have been grouped thematically (A-F) and the numbered subcategories cover the types of metadata entered for every
 5 population within the LPI database. For more information on the definitions and categories see the LPI website supporting
 6 documents section (https://www.livingplanetindex.org/supporting_documents).

7

1 **Supplementary Figure 6**



2
3
4
5
6
7

Growth in populations and species in the Living Planet Database. Line shows incremental increase in number of populations in the LPD. Bars show number of species in each Living Planet Report. Minimum estimates for numbers of populations were made for years 1998 to 2004 (*)

8 **Supplementary Table 7**

Marine priorities ranked by proportional difference		
Rank	Realm	Taxa
1	Tropical and Sub-tropical Indo-Pacific	Fishes
2	Temperate and Antarctic	Fishes
3	Atlantic Tropical and Sub-tropical	Fishes

9 **Top three marine groups with the highest proportional difference between observed and expected number of species for**
 10 **the LPI dataset in August 2020.** Where observed is the number of species in the dataset and expected is the current estimated
 11 number of extant species for that group (see ⁴ for data sources used).

12

1 Supplementary Table 8

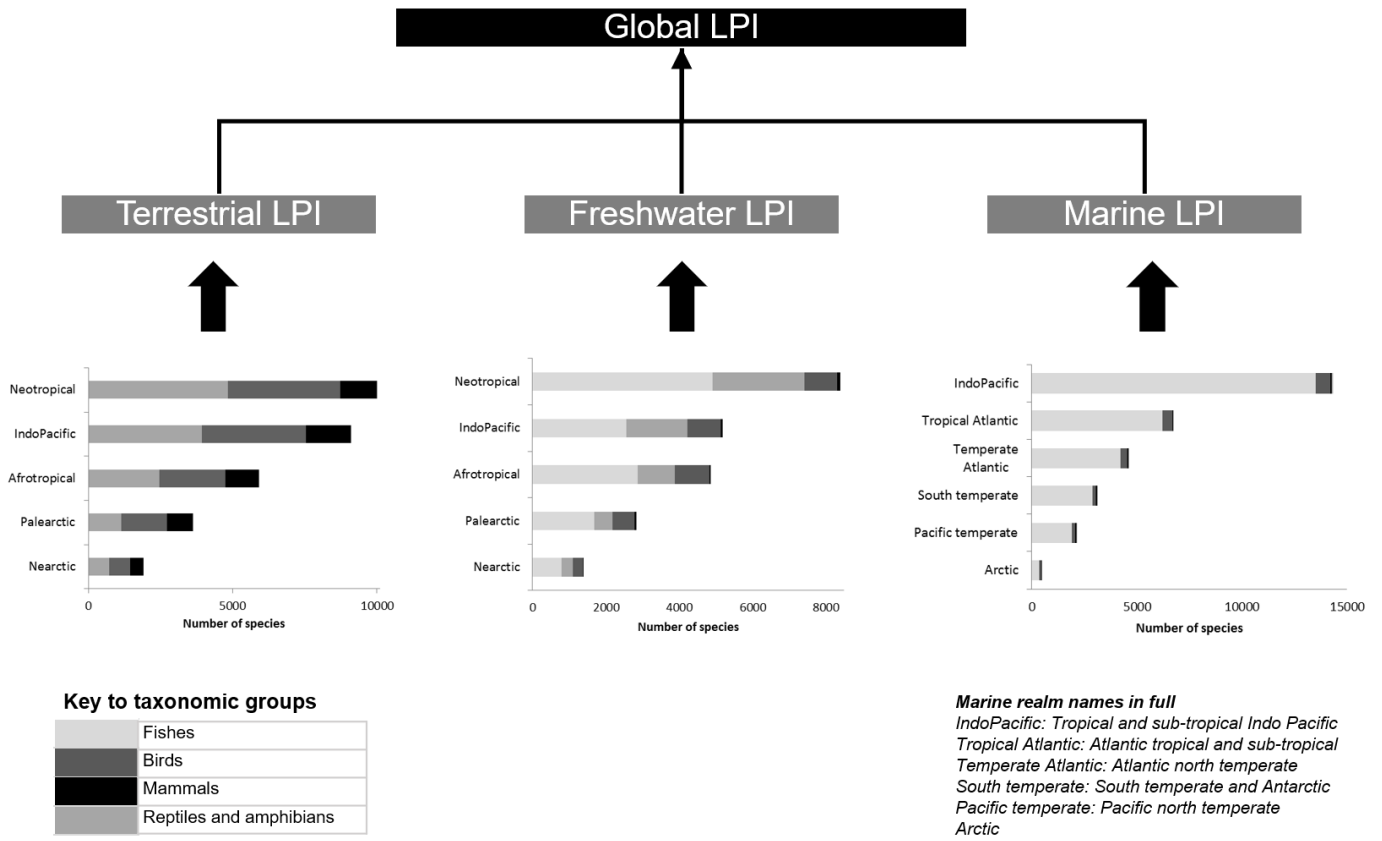
Terrestrial priorities ranked by proportional difference		
Rank	Realm	Taxa
1	Neotropical	Fishes
2	Indo-Malaya	Fishes
3	Afrotropical	Fishes
4	Neotropical	Reptiles
5	Afrotropical	Reptiles
6	Indo-Malaya	Reptiles
7	Neotropical	Amphibians
8	Afrotropical	Amphibians
9	Indo-Malaya	Amphibians
10	Palaearctic	Fishes

2 **Top 10 terrestrial and freshwater groups with the highest proportional difference between observed and expected number**
3 **of species for the LPI dataset in August 2020.** Where observed is the number of species in the dataset and expected is the
4 current estimated number of extant species for that group (see ⁴ for data sources used)

5

6

1 **Supplementary Figure 7**



2

3 **A visualisation of the weighting process for the global LPI.** Figure sourced from: McRae, et al. ⁴

4

1 **Supplementary References**

2 **Full citations for references used within the Supplementary Information document.**

- 3 1 Nuñez, M. A. & Amano, T. Monolingual searches can limit and bias results in global literature
4 reviews. *Nature Ecology & Evolution* **5**, 264-264, doi:10.1038/s41559-020-01369-w (2021).
- 5 2 Collen, B. *et al.* Monitoring change in vertebrate abundance: The Living Planet Index. *Conservation*
6 *Biology* **23**, 317-327, doi:10.1111/j.1523-1739.2008.01117.x (2009).
- 7 3 Loh, J. *et al.* The Living Planet Index: Using species population time series to track trends in
8 biodiversity. *Phil. Trans. R. Soc. B* **360**, 289-295, doi:10.1098/rstb.2004.1584 (2005).
- 9 4 McRae, L., Deinet, S. & Freeman, R. The diversity-weighted Living Planet Index: Controlling for
10 taxonomic bias in a global biodiversity indicator. *PLoS ONE* **12**, e0169156,
11 doi:10.1371/journal.pone.0169156 (2017).
- 12 5 Butchart, S. H. *et al.* Global biodiversity: Indicators of recent declines. *Science* **328**, 1164-1168,
13 doi:10.1126/science.1187512 (2010).
- 14 6 Tittensor, D. P. *et al.* A mid-term analysis of progress toward international biodiversity targets.
15 *Science* **346**, 241-244, doi:10.1126/science.1257484 (2014).
- 16 7 WWF. Living planet report 2020 - Bending the curve of biodiversity loss. (WWF, Gland, Switzerland,
17 2020).
- 18 8 IPBES. in *Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem*
19 *Services. Third session.*

20