



# WWF-Canada - Technical Document

Date Completed: September 14, 2017

Technical Document – Living Planet Report Canada

## What is the Living Planet Index

Similar to the way a stock market index measures economic performance, a Living Planet Index (LPI) measures a nation's ecological performance<sup>i</sup>. The index is an indicator of broad patterns of wildlife abundance over time, and is calculated using multiple datasets for different populations of each of the vertebrate species included in the study. (One species, like the woodland caribou, for example, may have many different monitored populations.)

## Methods: Database

### DATABASE

More than 400 sources of data on species population sizes were included in the calculation of the Living Planet Index (LPI) for Canada, including peer-reviewed scientific literature, government monitoring (for example, Fisheries and Oceans Canada [DFO] Research Vessel Trawl Surveys) and citizen science (for example, the North American Breeding Bird Survey).<sup>ii</sup> Each record was populated with contextual information including a unique ID number, taxon, geographic region, and realm (freshwater, marine, and terrestrial), among others. Data for the contextual information identifiers were derived from the data sources themselves. Importantly, if a species belonged to more than one realm (e.g. salmon), or region, it was identified as belonging to the ecosystem or region where the population counts were actually conducted.

Some of the data was easily accessible for download from the Living Planet Index data portal,<sup>iii</sup> previously collected by the Zoological Society of London (ZSL) and WWF-

International. However, in order to increase the number of data records included in the LPI analysis, three entities (ZSL, the Canadian Environmental Sustainability Indicators [CESI] group at Environment and Climate Change Canada [ECCC] and WWF-Canada) worked to obtain additional data on population trends for wildlife in Canada. WWF-Canada contributed monitoring data for 418 species, more than 2,000 populations, and 86 data sources to the centralized Living Planet dataset for Canada, providing a more robust and accurate analysis of wildlife trends in a national context. At the present time, a portion of the database included in the LPI analysis is downloadable from the Living Planet Index data portal.<sup>iii</sup> Confidential records have been withheld from public access.

## CRITERIA FOR INCLUSION

Criteria for the inclusion of species population data in Living Planet Report Canada (LPRC) followed the methods of previous international Living Planet reports, as developed by the ZSL,<sup>i</sup> and a common methodology for a national approach was established with ECCC.

- Populations must be consistently monitored in the same location, using the same method over time, for a minimum of two consecutive years.
- Data must be numerical (i.e., a population count or a reliable population-size proxy, such as population estimates, spawning biomass, catch-per-unit effort, density, etc.).
- Population data must be available for at least two years in the period between 1970 and 2016. (A lack of available data in 2015 and 2016 – primarily due to a lag in scientific publishing – meant trends in the index are reported to 2014.)
- Data sources must be referenced and traceable.
- In addition to the international criteria developed by ZSL, for this national-scale study, species must be native to the country, as defined in the 2015 Wild Species Report.<sup>iv</sup>

## TREATMENT OF REPLICATES

Nationally, the LPI database included national-scale data in place of regional data. This replacement of data was only applicable for the bird taxon, in which

population counts were available from the North American Breeding Bird Survey for both regional and national scales. In addition, to avoid overrepresentation of regions where multiple data records were available for the same species in a specific region (e.g. NAFO division 4T), replicates were removed to account for geographic sampling bias. During the process of removing replicates, priority for inclusion was given to (i) longer time-series, (ii) more recent data, and (iii) quality of the study.

For the regional sub-indices calculated in Chapter 5 of the LPRC, replicates were reinstated to strengthen the data and number of records contributing to each geographic LPI. Moreover, for these sub-indices, regional-scale data was used in place of the national-scale data, with respect to the bird trends included from the North American Breeding Bird Survey. The number of species and records included in the national and regional datasets are outlined in Table 1.

## TREATMENT OF ZEROS

Calculation of the Living Planet Index differed from Collen *et al.* (2009)<sup>i</sup> in one aspect: the treatment of zeros. In calculating the Living Planet Index, population counts of zero — where a species was not observed in a given year, or where local populations of species may have already gone extinct — were treated as missing values, due to limitations with respect to the calculation of the geometric mean. Mathematically, a number cannot be divided by zero.

In order to include population counts of zero in the analysis, it is possible to add a small quantity to zeros, for mathematical purposes. For instance, Collen *et al.* (2009)<sup>i</sup> added one per cent of the mean population measure value for the time series for years in which there was a population count of zero. However, an analysis of the geometric mean of relative abundance indices<sup>v</sup> argues that the index is sensitive to the quantity chosen to replace a zero. In addition, the analysis exhibits high variance and instability when rarely recorded species are included. Rarely recorded species are populations that have multiple zeros throughout the length of their time series. For this reason, population counts of zero were treated as missing values for the purpose of calculating a national LPI for Canada. The decision to eliminate population counts of zero was made in conjunction with Environment and Climate Change Canada. Consequently, the index

figures included in the LPRC can therefore be interpreted as conservative estimates of change, as population losses could be greater than the index suggests, especially if population counts of zero were recorded at the end of a time series.

## Methods: Population Modelling

The statistical code for running the Living Planet Index was adapted from the Zoological Society of London's publicly available R-Statistical package on GitHub.<sup>vi</sup> For consistency with the international Living Planet Report<sup>vii</sup>, index values were calculated with a baseline year of 1970. Importantly, changes in wildlife populations had occurred before 1970 and were likewise not reflected in the results reported in the LPRC. The R-statistical package from GitHub was created following the methods outlined in Collen *et al.* (2009)<sup>i</sup> to calculate a geometric mean of relative abundance indices, which are reported as percent changes since 1970. Simply put, the LPI was calculated by averaging trends in monitored populations to create a trend in abundance for each unique species. These trends were then averaged across all species to generate the LPI. The LPI was calculated with 10,000 bootstraps, creating confidence limits for inclusion as an assessment of uncertainty.

Time series (population trends) with at least six data points were modelled using a Generalized Additive Model ( $n = 1,284$ ). Alternatively, shorter time series were calculated using a linear regression model ( $n = 2,405$ ). (Details regarding the mathematics of the calculation are outlined in the methods paper).<sup>i</sup> Importantly not all time series began in 1970, and ended in 2014. In fact, the majority (65 per cent) were very short, and were therefore calculated using the latter model.

The quality of the data affecting the overall trends is driven primarily by time series fullness (the number of years for which there is a population count), and length (which includes interpolation between years). For the national Living Planet Index, the mean time series fullness and length was 12.44 years ( $n = 3,689$ ), and 15.05 years, respectively. Data quality contributing to the index was enhanced by fish and birds, which were the most robust taxonomic groups in terms of time series fullness and

length (with large datasets from Fisheries and Oceans Canada Research Vessel Trawl Surveys, and the North American Breeding Bird Survey).

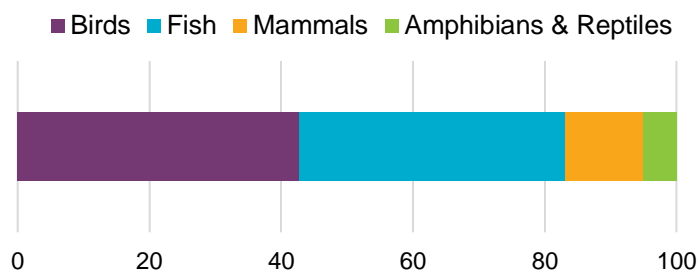
Recent studies utilizing the Living Planet Index have employed an additional mathematical element to overcome taxonomic and geographic bias of biodiversity trends through weighting<sup>viii</sup>. However, in the LPRC, monitored populations were weighted equally within species, and species were weighted equally within the index.

## Results: Summary of Species & Records

The national Living Planet Index examined the status of 903 vertebrate species in Canada, representing over half of the country's native vertebrate animals. The index included trend data from 3,689 monitored populations (data records) between 1970 and 2014.

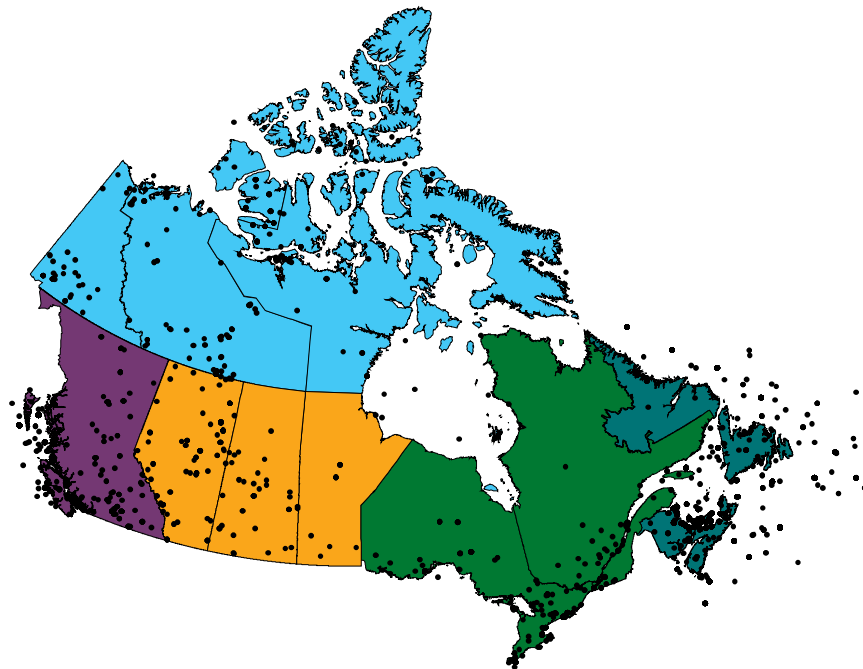
Birds and fish were the primary taxonomic groups in the national index, accounting for 43 per cent and 40 per cent of the species in the study, respectively (Figure 1). This is unsurprising, given that there are substantially more bird and fish species found in Canada, in comparison to other vertebrate species. The national LPI also included mammals (12 per cent) and amphibians and reptiles (5 per cent).

Birds were the best-represented taxon included in the index, where trend data was captured for approximately 85 per cent of all native bird species in Canada. Population counts were available for approximately half of all mammals, and amphibians and reptiles. Though population trend data was available for hundreds of fish species, the fish taxon was comparatively poorly represented, given that over 1,000 fish species are native to Canada. Consequently, the index captured only one third of native fish species in Canada.



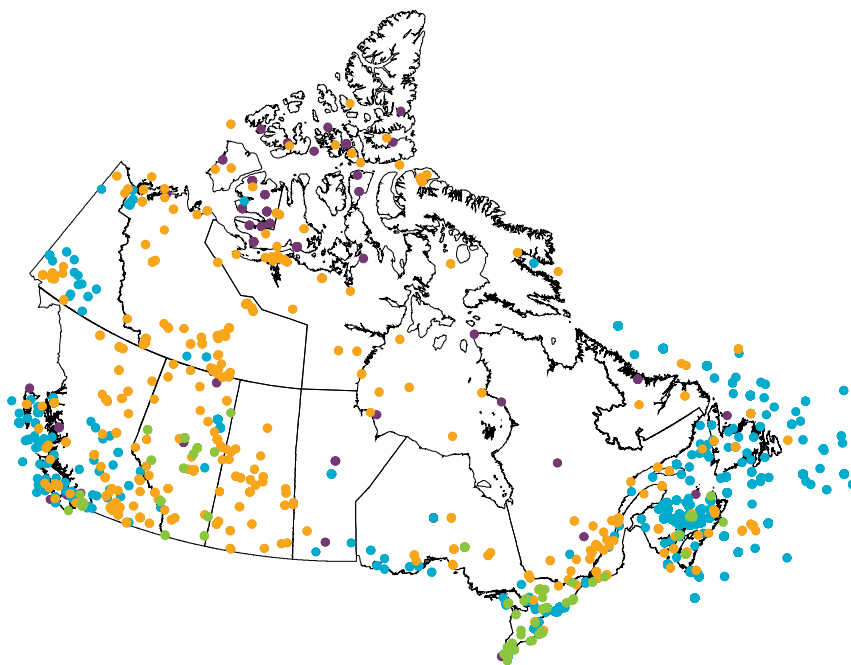
**Figure 1. Relative proportion of major species groups included in the LPI (903 vertebrate species).**

Data was collected nation-wide, and grouped into five regions (Atlantic, Central, Prairies, Pacific and Arctic) that were selected based on the spatial distribution of data records obtained (Figure 2). Though a provincial and territorial, or ecozone breakdown would have been preferable, the five selected regions were the smallest geographic division that the data allowed for, to acquire results of relative confidence. Effort was made to collect data that was well-distributed spatially across the country, aiming for equal representation within each of the geographic regions (Figure 1). Nevertheless, more data was publicly available for the Pacific (B.C., Pacific Ocean), and Atlantic (N.B., N.S., P.E.I., N.L., Atlantic Ocean) areas of Canada, in comparison to the other three regions (Table 1). Central Canada (Que., Ont.) and the Prairies (Man., Sask., Alta.) consist only of two realms (freshwater and terrestrial). Consequently, it is somewhat unsurprising that there was comparably fewer species and data records contributing to these regions. The Arctic (Yukon, N.W.T., Nunavut, Arctic Ocean) was the most poorly represented region, despite containing three broad realms.



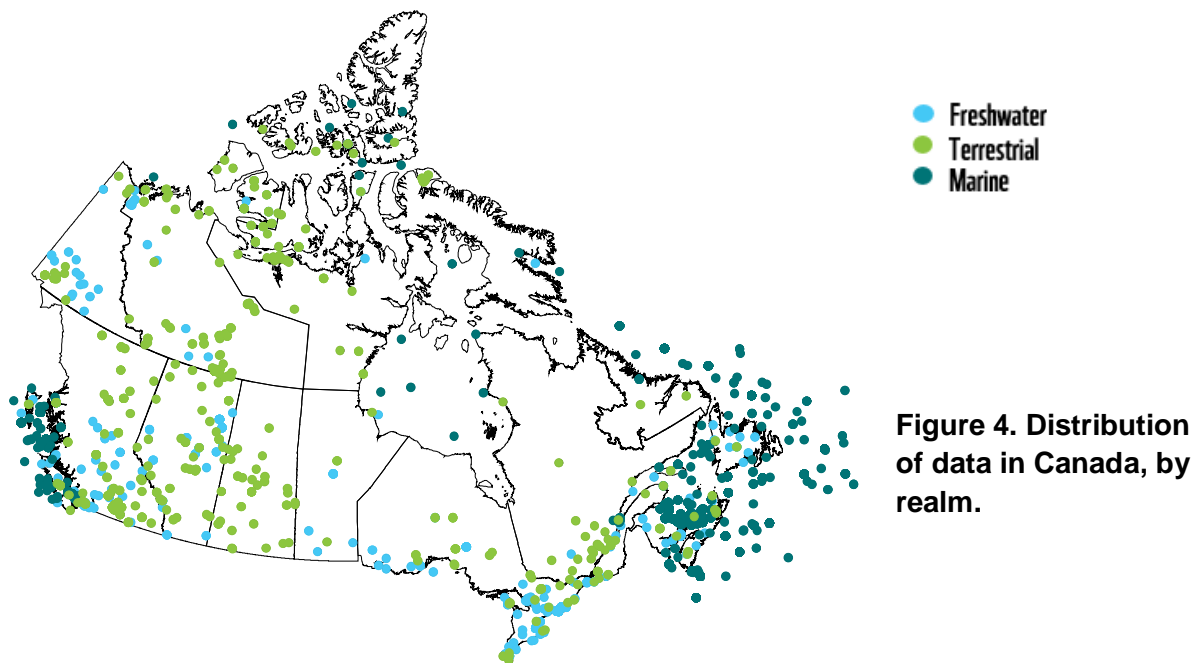
- Pacific
- Prairies
- Central
- Atlantic
- Arctic

**Figure 2. Distribution of data across the five geographic areas of Canada.**



- Birds
- Mammals
- Fish
- Reptiles & Amphibians

**Figure 3. Distribution of data in Canada, by taxon.**



**Figure 4. Distribution of data in Canada, by realm.**

**Table 1. Spatial distribution of data (number of species and data records) for national (indices for Chapters 1-4) and regional (indices for Chapter 5) datasets contributing to the database for the Living Planet Index.**

Region	National		Regional	
	# Species	# Data Records	# Species	# Data Records
Atlantic	192	1,837	364	2,772
Central	119	321	313	689
Prairies	78	185	315	791
Pacific	228	753	452	1,035
Arctic	63	266	224	639
Canada-wide	327	327	NA	NA



## Results: Outputs

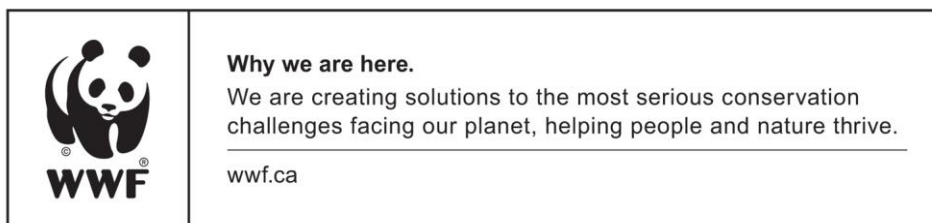
Though nearly 100 LPIs were calculated based on available population data, only 22 trend lines were reported in LPRC. Each LPI was evaluated for data robustness in terms of the strength of the underlying data, the number of species included, and the total number of records. In addition, each trend that was included was validated through scientific literature reviews, and consultation with external species experts. Therefore, trends with small sample size and large confidence limits that were incongruent with scientific knowledge were not reported in LPRC. Results for all the LPIs included in the LPRC are summarized in Table 2.

**Table 2. Summary of Living Planet Index results for trends included in Living Planet Report Canada. The table includes the number of species and records included in each LPI, in addition to the overall trend (%) and range (high to low; %).**

LPI	# Species	# Records	Trend (%)	High (%)	Low (%)
National	903	3689	-8	-2	-14
National Declines	451	2066	-83	-81	-84
SARA [all]	87	256	-63		
SARA 1970-2002	64	184	-43	-32	-52
SARA 2002-214	64	154	-28	-14	-41
COSEWIC	61	335	-64	-54	-71
Terrestrial	334	784	-9	-1	-16
Marine	367	2313	-9	5	-21
Freshwater	222	592	5	21	-9
Lake Ontario fish	34	117	-32	9	-57
Mammals	106	549	-43	-13	-63
Birds	386	474	7	11	2
Grassland Birds	26	26	-69		
Shorebirds	37	40	-43		
Waterfowl	38	66	54		
Aerial Insectivores	27	27	-51		
Raptors	20	29	88		
Fish	365	2527	-20	-5	-32
Amphibians & Reptiles	46	139	-34	40	-69
Atlantic Marine Fish	139	2224	-38	-24	-50
Central Amphibians & Reptiles	28	73	-16	69	-59
Prairie Grassland Birds	23	62	-55	-50	-60
Pacific Freshwater	68	140	-14	-3	-23

## References

- <sup>i</sup> Collen, B. *et al.* 2009. Monitoring change in vertebrate abundance: the Living Planet Index. *Conservation Biology*. 23(2): 317-327.
- <sup>ii</sup> ECCC. Breeding bird survey results. *Environment Canada & Climate Change*. Retrieved online (2017) at: <https://wildlife-species.canada.ca/breeding-bird-survey-results>
- <sup>iii</sup> WWF-International & ZSL. 2017. Living Planet Index. *World Wildlife Fund International & the Zoological Society of London*. Retrieved online (2017) at [http://www.livingplanetindex.org/data\\_portal](http://www.livingplanetindex.org/data_portal)
- <sup>iv</sup> CESSC. 2016. Wild Species 2015: The general status of species in Canada. National General Status Working Group: Canadian Endangered Species Conservation Council. 128 pp.
- <sup>v</sup> Buckland, S.T. *et al.* 2011. The geometric mean of relative abundance indices: a biodiversity measure with a difference. *Ecosphere*. 2(9): 100.
- <sup>vi</sup> ZSL. Zoological Society of London rLPI. *Zoological Society of London*. Retrieved online (2017) at <https://github.com/Zoological-Society-of-London/rspi>.
- <sup>vii</sup> WWF-International. 2016. Living planet report 2016: Risk and resilience in a new era. *World Wildlife Fund Canada*. 144 pp.
- <sup>viii</sup> McRae, L. *et al.* 2017. The diversity-weighted Living Planet Index: Controlling for taxonomic bias in a global biodiversity indicator. *PLoS ONE*. 12(1): e0169156.



© 1986 Panda symbol WWF-World Wide Fund For Nature (also known as World Wildlife Fund).  
® “WWF” is a WWF Registered Trademark.