The Living Planet Index: How to turn lemons into lemonade!

Biodiversity Modelling Summer School:
Indicators to monitor biodiversity changes
May 14 2024

Today

Indicators: A brief overview

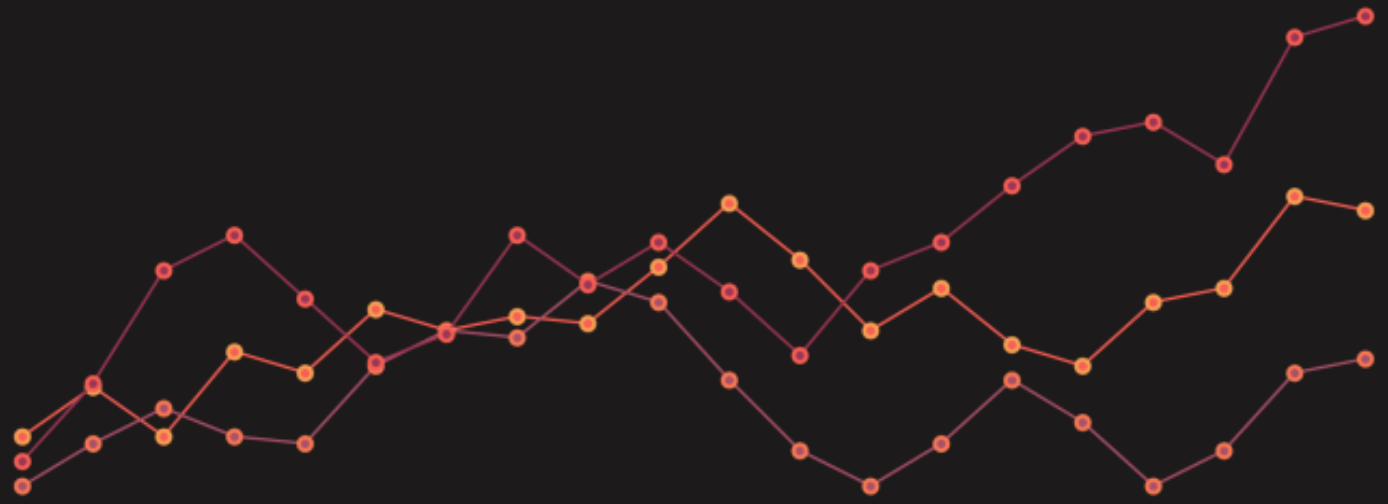
- What are they & why do we need them?

The Living Planet Index: the lemons & the lemonade

1. The data
2. The baseline
3. The average trend
4. Variation: uncertainty & correlated trends

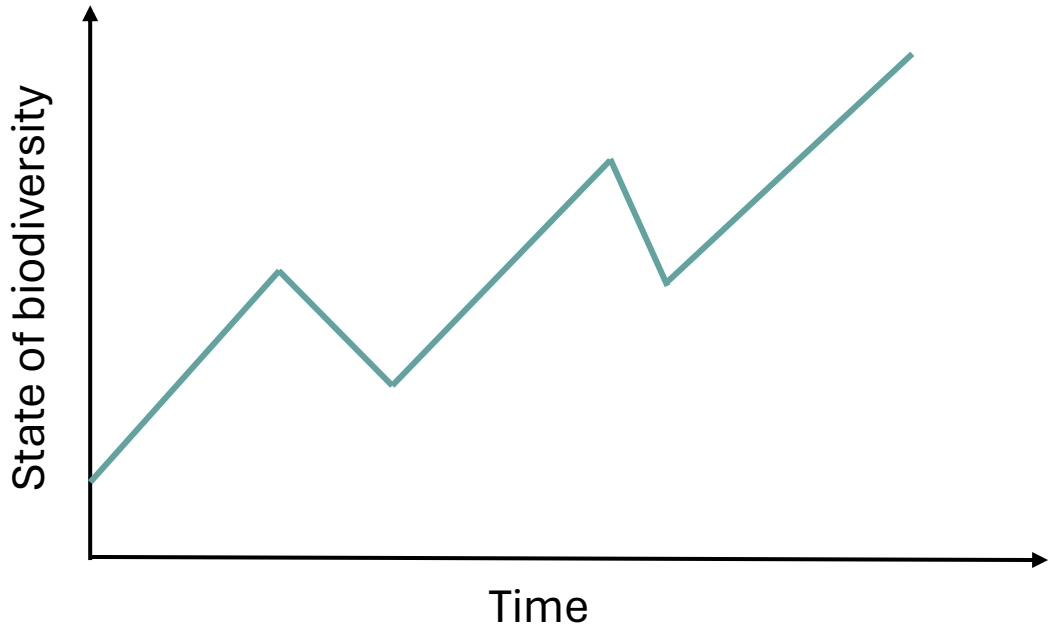
How to make lemonade: How can we use (and improve) imperfect indicators?

1. Biodiversity indicators



Biodiversity indicators: What are they?

A metric that **summarises** the **state** of biodiversity at **different points in time** to draw **inferences** about changes in that state. Jones et al. (2010)



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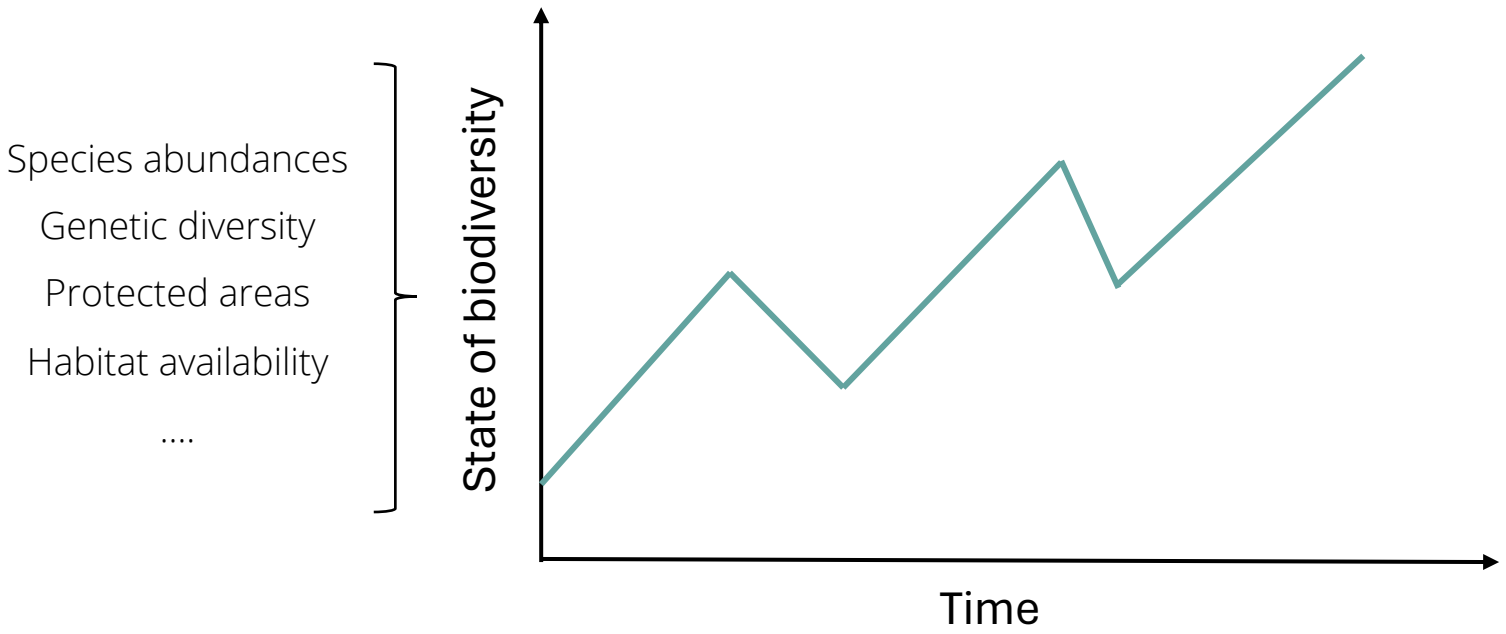

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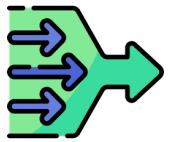
Why do we need indicators?

Indicators are essential tools to track progress towards the Global Biodiversity Framework (GBF) targets and goals.

Over 150 indicators have been proposed for the GBF!

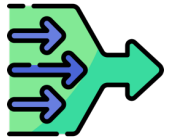
Biodiversity indicators: Why are they useful?



Summarise complicated things into a single number or trend

- Decision-making & communication

Biodiversity indicators: Why are they useful?



Summarise complicated things into a single number or trend

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Compare the state of biodiversity across countries

- Standard evaluation of progress towards targets

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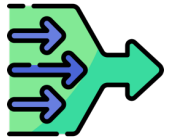

Summarise complicated things into a single number or trend

- Decision-making & communication

Compare the state of biodiversity across countries

- Standard evaluation of progress towards targets

Evaluate the current state relative to a baseline or target

- Quantitative assessment of “how we’re doing” at maintaining and protecting biodiversity

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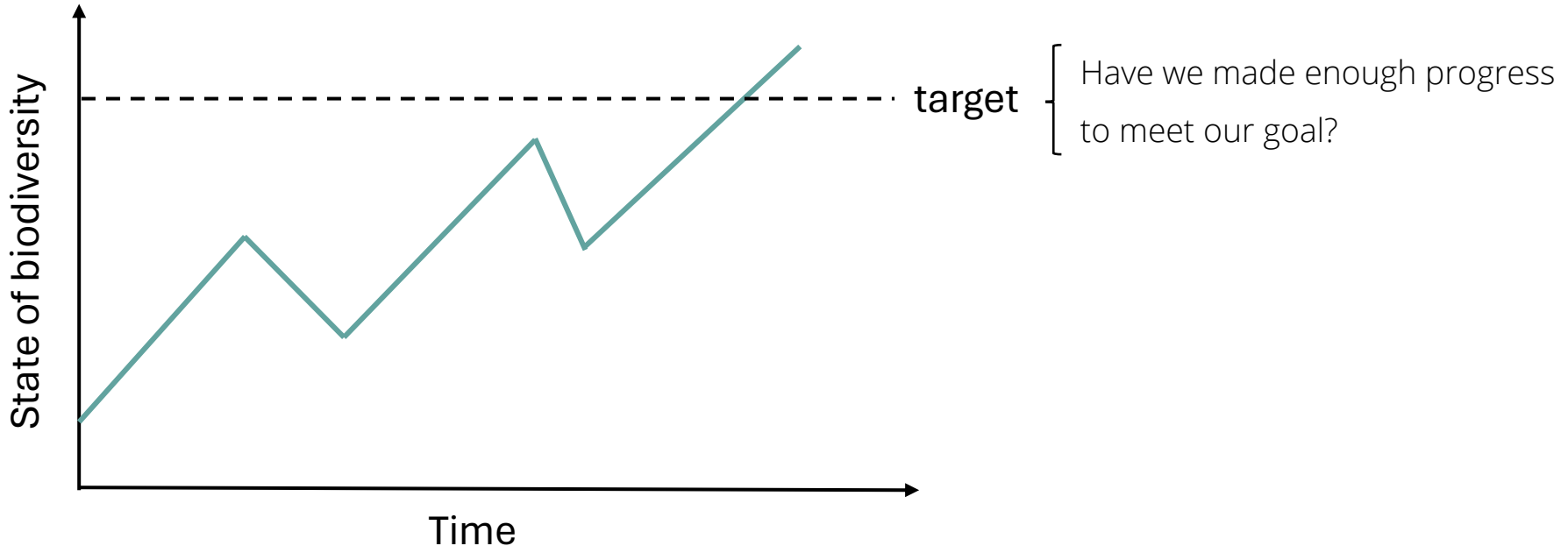

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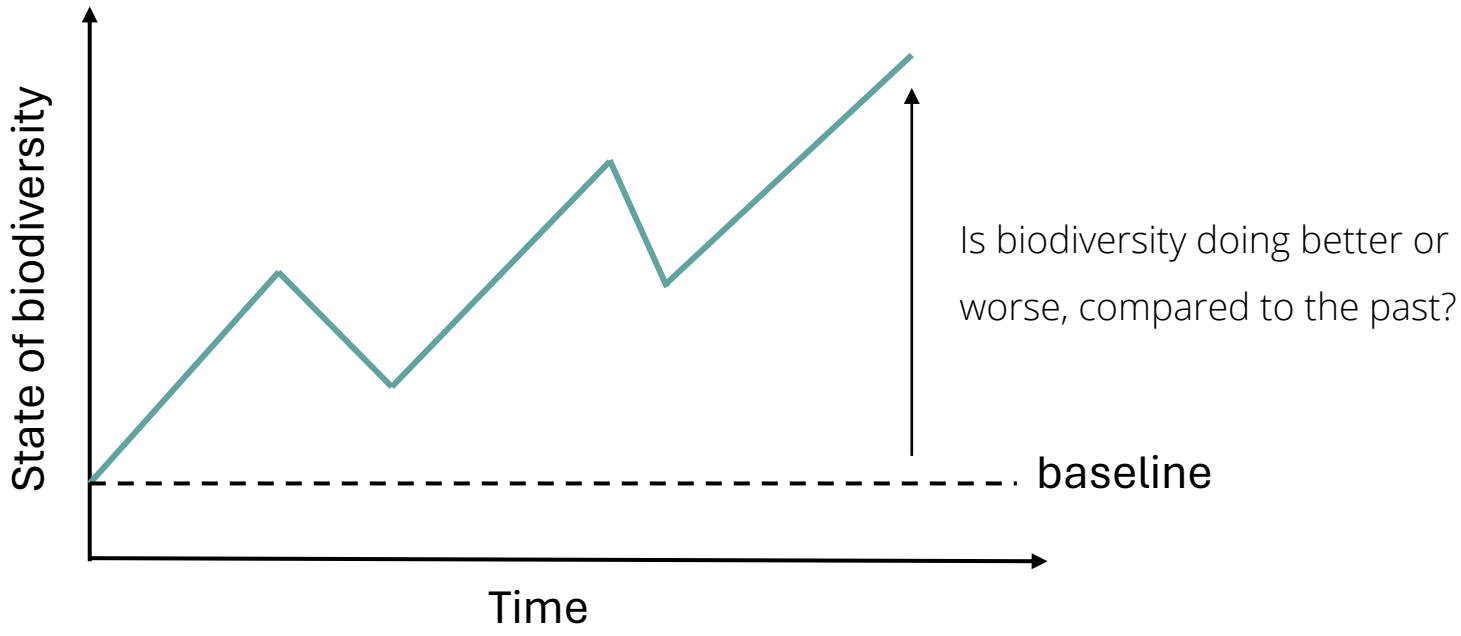

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Biodiversity indicators: A challenge

Indicators summarise biodiversity change, and we need these summaries to make decisions.

Simplifying vs. Capturing complexity

- When we simplify, we *lose* some information.
- When we keep everything, we keep *all the complexity*.

Sacrificing some information can make it **easier to highlight an essential message**.

But how much information is okay to sacrifice?

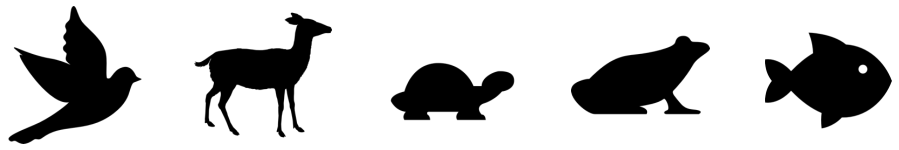
2. The Living Planet Index

The Living Planet Index

- **Component indicator** in the Kunming-Montreal Global Biodiversity Framework.

The Living Planet Index

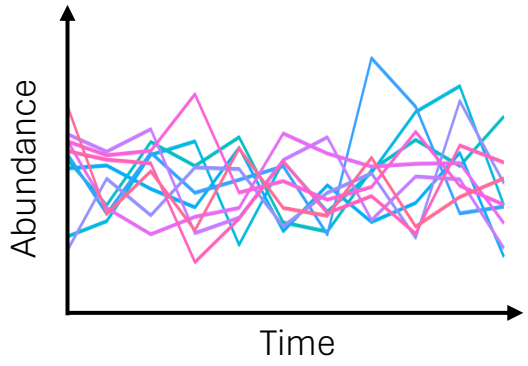
- **Component indicator** in the Kunming-Montreal Global Biodiversity Framework.
- Tracks the change in wildlife abundance for birds, mammals, reptiles, amphibians, and fish populations, relative to 1970.



The Living Planet Index

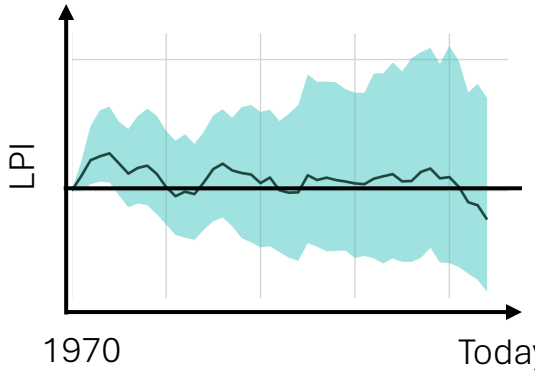
Essential Biodiversity Variable

Species abundances



Indicator

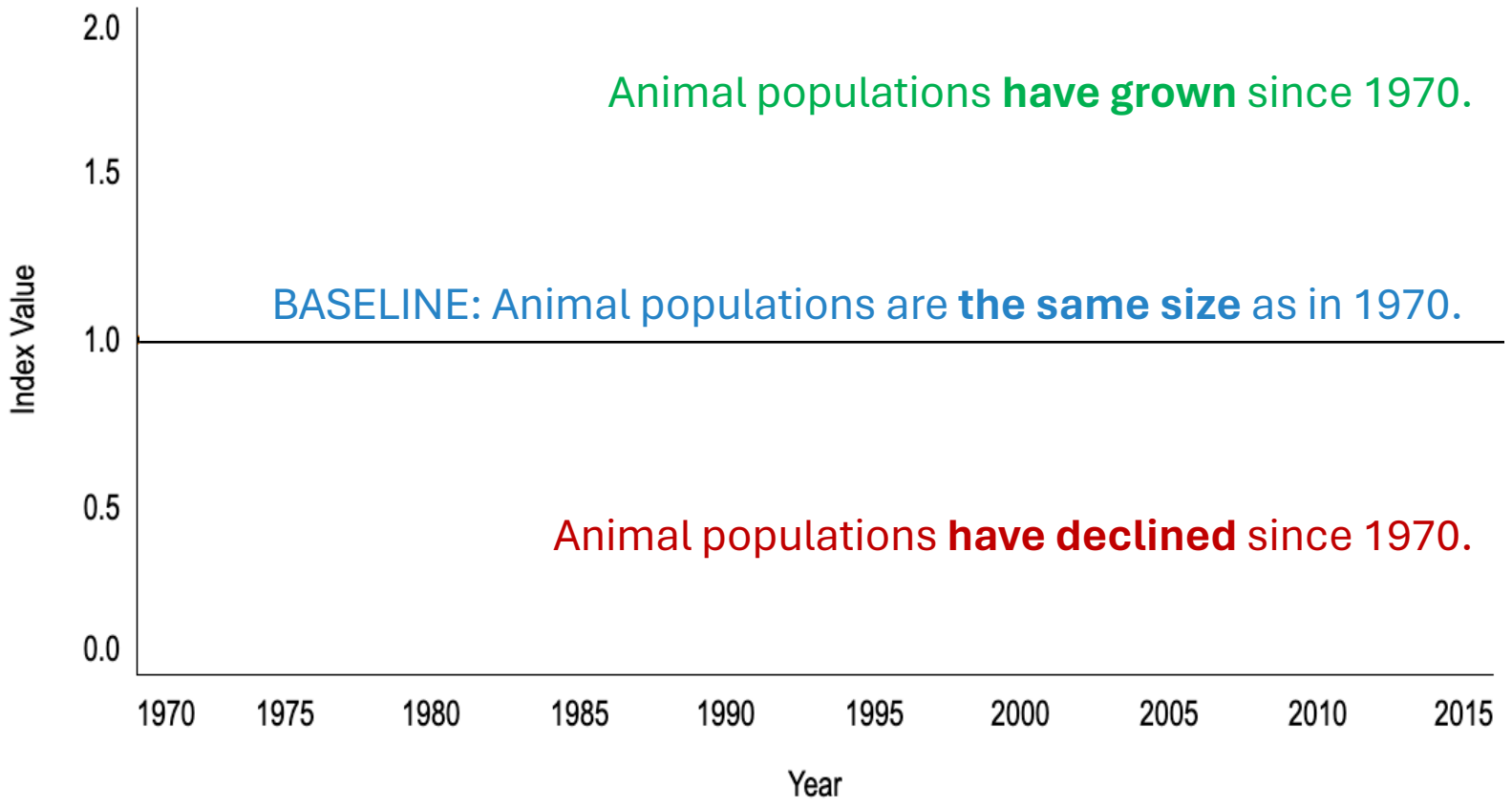
Living Planet Index



Target

Halting biodiversity loss

The Living Planet Index Interpretation guide



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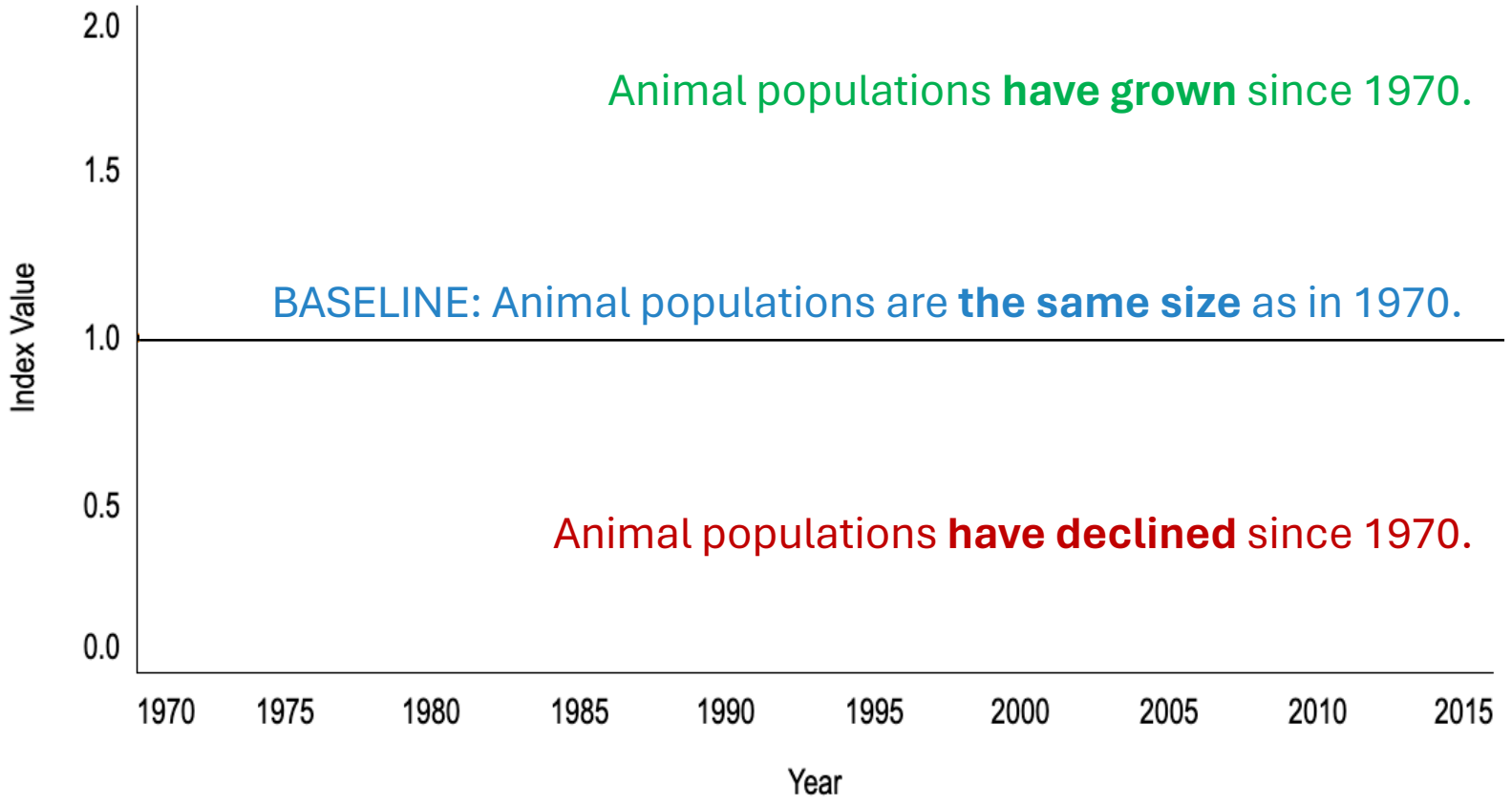
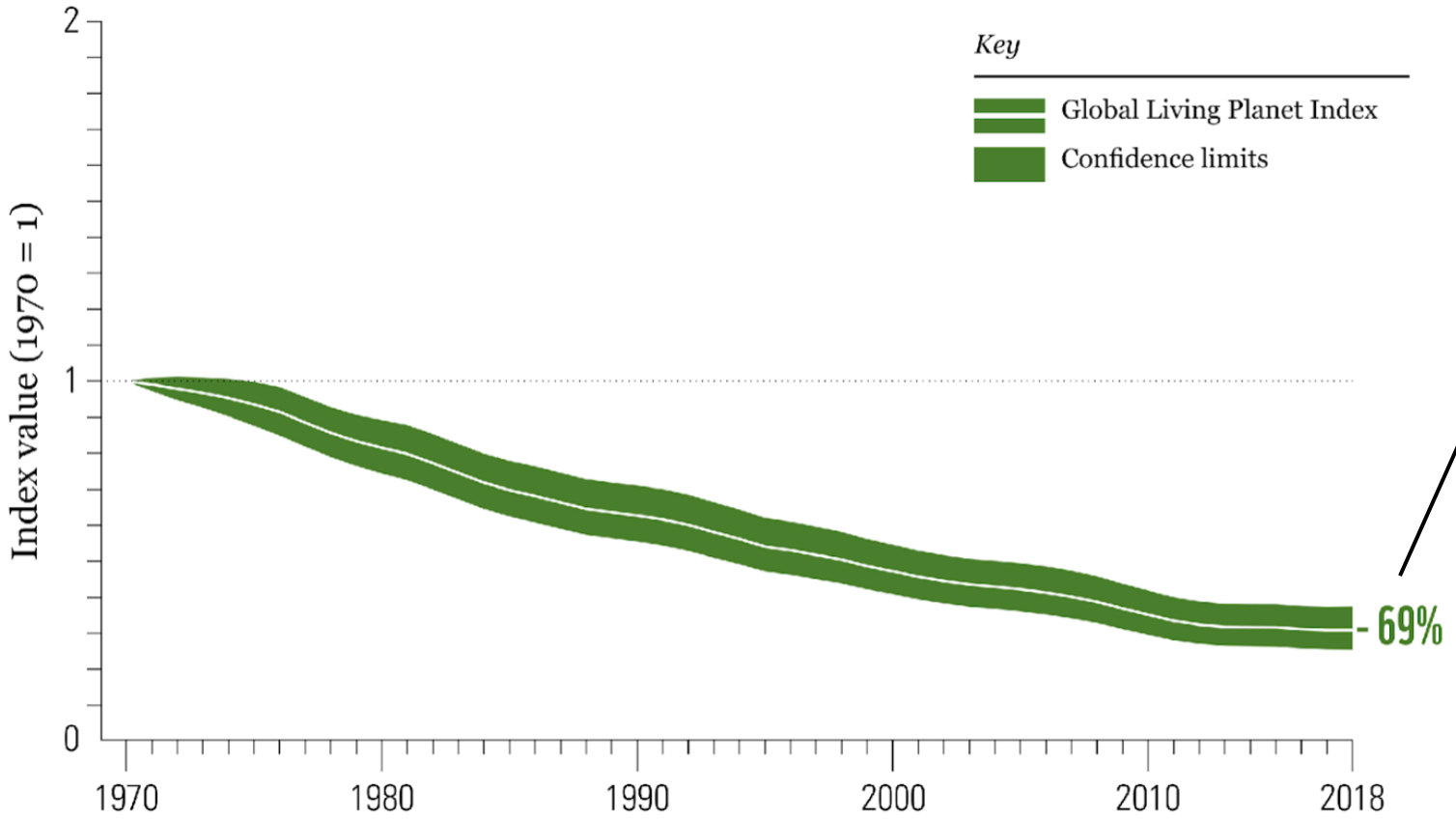


The state of biodiversity is improving!

The state of biodiversity is stable: it's not better, but it's not worse!

The state of biodiversity is deteriorating.

Living Planet Index: Global



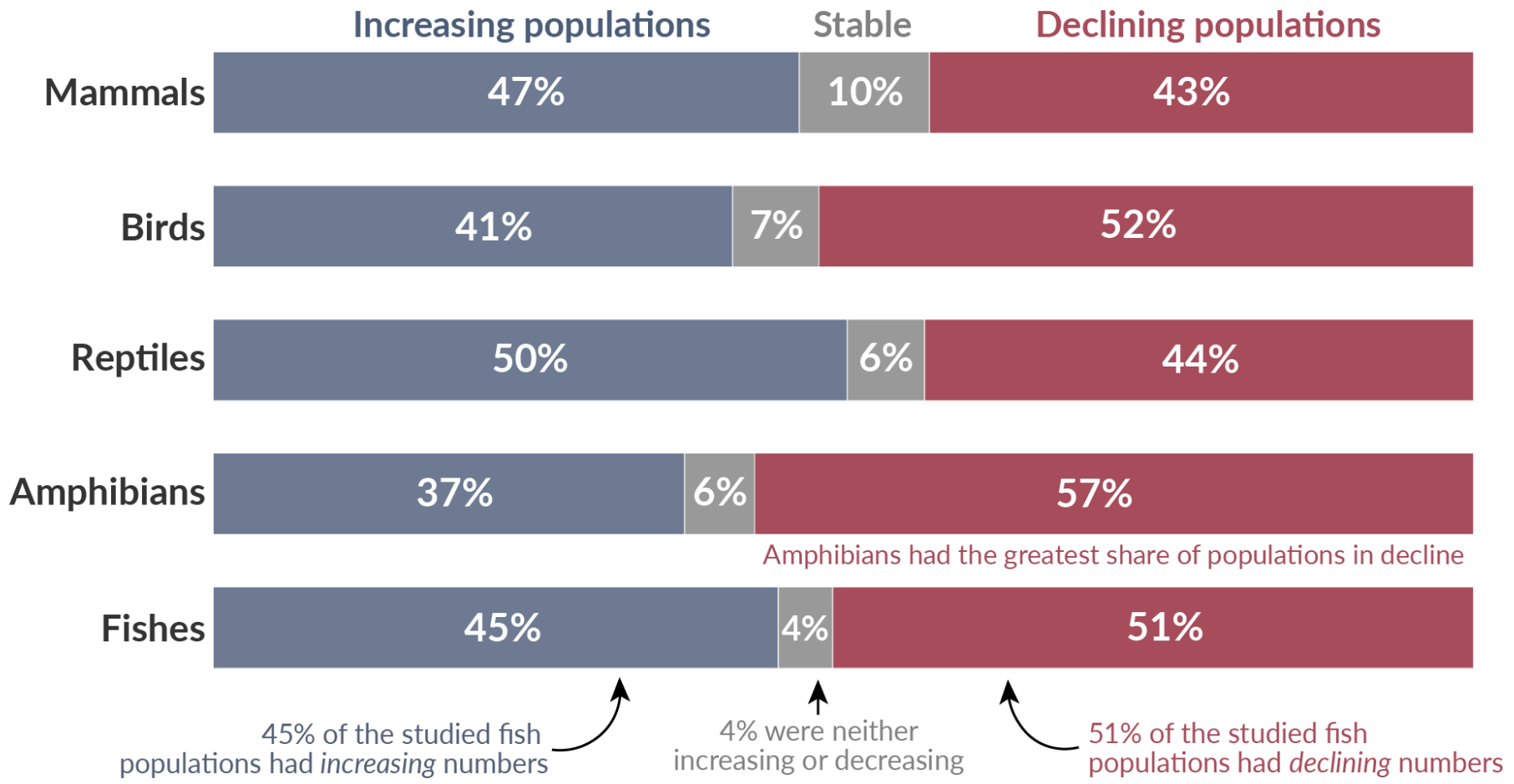
Vertebrate populations **are 69% smaller than they were** in 1970.

The state of biodiversity is deteriorating.

Global Living Planet Index: how are wildlife populations changing?

Shown is the share of studied populations in each taxonomic group with increasing, stable or declining abundance.
The 2022 Living Planet Index reported a 69% average decline in wildlife populations since 1970.

Around half of populations are increasing, and half are in decline.



Source: WWF (2022). Living Planet Report 2022 – Building a nature positive society. Almond, R.E.A., Grooten, M., Juffe Bignoli, D. & Petersen, T. (Eds).

3. The lemons

Article

Clustered versus catastrophic global vertebrate declines

https://doi.org/10.1038/s41586-020-2920-6

Received: 28 January 2020

Accepted: 4 September 2020

Check for updates

Brian Leung[1,2✉], Anna L. Hargreaves[1], Dan A. Greenberg[3], Brian McGill[4,5], Maria Dornelas[6] & Robin Freeman[7]

Recent analyses have reported catastrophic global declines in vertebrate populations[1,2]. However, the distillation of many trends into a global mean index obscures the variation that can inform conservation measures and can be sensitive to analytical decisions. For example, previous analyses have estimated a mean vertebrate decline of more than 50% since 1970 (Living Planet Index[2]). Here we show, however, that this estimate is driven by less than 3% of vertebrate populations; if these extremely declining populations are excluded, the global trend switches to an increase. The sensitivity of global mean trends to outliers suggests that more informative indices are needed. We propose an alternative approach, which identifies clusters of extreme decline (or increase) that differ statistically from the majority of population trends. We show that, of taxonomic–geographic systems in the Living Planet Index, 16 systems contain clusters of extreme decline (comprising around 1% of populations; these extreme declines occur disproportionately in larger animals) and 7 contain extreme increases (around 0.4% of populations). The remaining 98.6% of populations across all systems showed no mean global trend. However, when analysed separately, three systems were declining strongly with high certainty (all in the Indo-Pacific region) and seven were declining strongly but with less certainty (mostly reptile and amphibian groups). Accounting for extreme clusters fundamentally alters the interpretation of global vertebrate trends and should be used to help to prioritize conservation efforts.

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Matters arising

Do not downplay biodiversity loss

https://doi.org/10.1038/s41586-021-04179-7
Received: 12 January 2021
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Published online: 26 January 2022
Check for updates

Michel Loreau[1]✉, Bradley J. Cardinale[2], Forest Isbell[3], Tim Newbold[4], Mary I. O'Connor[5] & Claire de Mazancourt[1]

ARISING FROM B. Leung et al. *Nature* https://doi.org/10.1038/s41586-020-2920-6 (2020)

Matters arising

The Living Planet Index does not measure abundance

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Mikael Puurtinen[1,2]✉, Merja Elo[1,2] & Janne S. Kotiaho[1,2]

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Emphasizing declining populations in the Living Planet Report

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Gopal Murali[1,2,5], Gabriel Henrique de Oliveira Caetano[1,2,5], Goni Barki[2,3,5], Shai Meiri[4,6] & Uri Roll[2,6]✉

ARISING FROM B. Leung et al. *Nature* https://doi.org/10.1038/s41586-020-2920-6 (2020)

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Shifting baselines and biodiversity success stories

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Received: 4 December 2020
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Published online: 26 January 2022
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Zia Mehrabi[1]✉ & Robin Naidoo[2,3]✉

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Reply to: Do not downplay biodiversity loss

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Published online: 26 January 2022
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REPLYING TO M. Loreau et al. *Nature* https://doi.org/10.1038/s41586-021-04179-7 (2022)

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ARISING FROM B. Leung et al. *Nature* https://doi.org/10.1038

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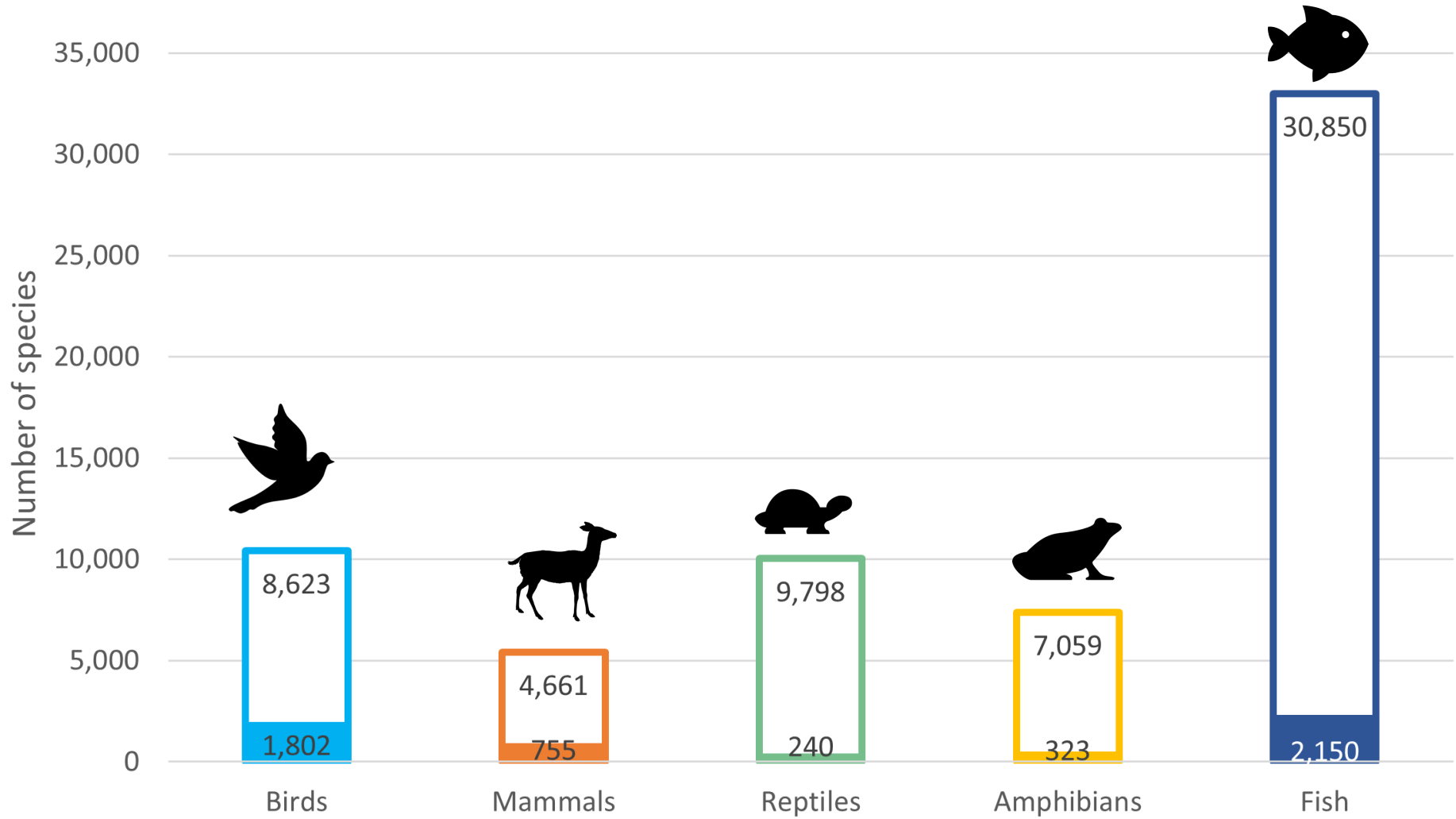
REPLYING TO Z. Mehrabi & R. Naidoo *Nature* https://doi.org/10.1038/s41586-021-03750-6 (2022)

The data

The database relies on the literature, so it does not perfectly represent biodiversity.

Taxonomic biases



Geographic biases

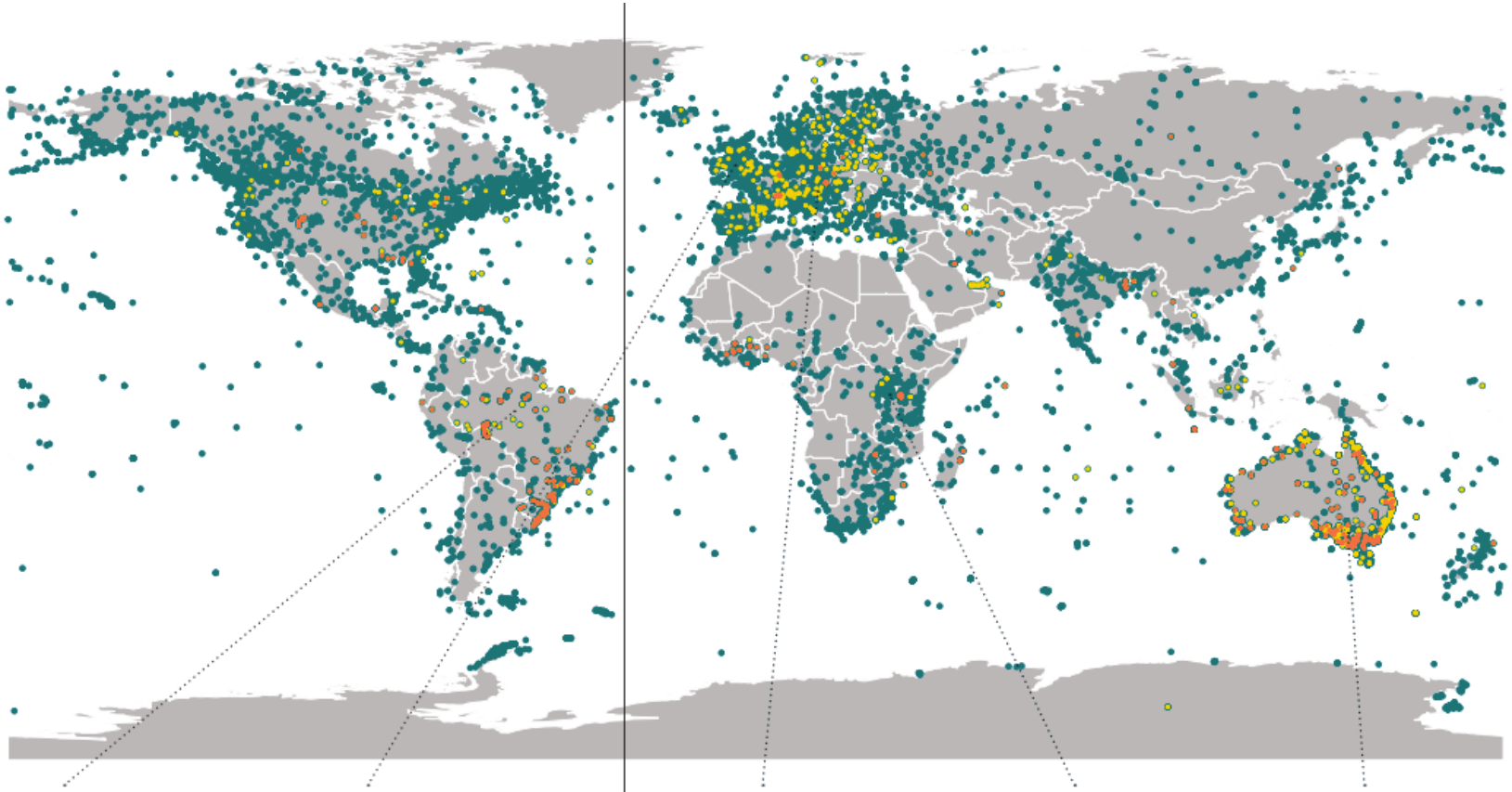


Figure 6: Locations of animal populations used for the Living Planet Index
WWF/ZSL (2022)[1].

Key

- New populations
- New species
- Existing data

LATIN AMERICA (BRAZIL)
Amazon pink river dolphins (*Inia geoffrensis*) in the Mamirauá Sustainable Development Reserve declined by 65% between 1994 and 2016[7].

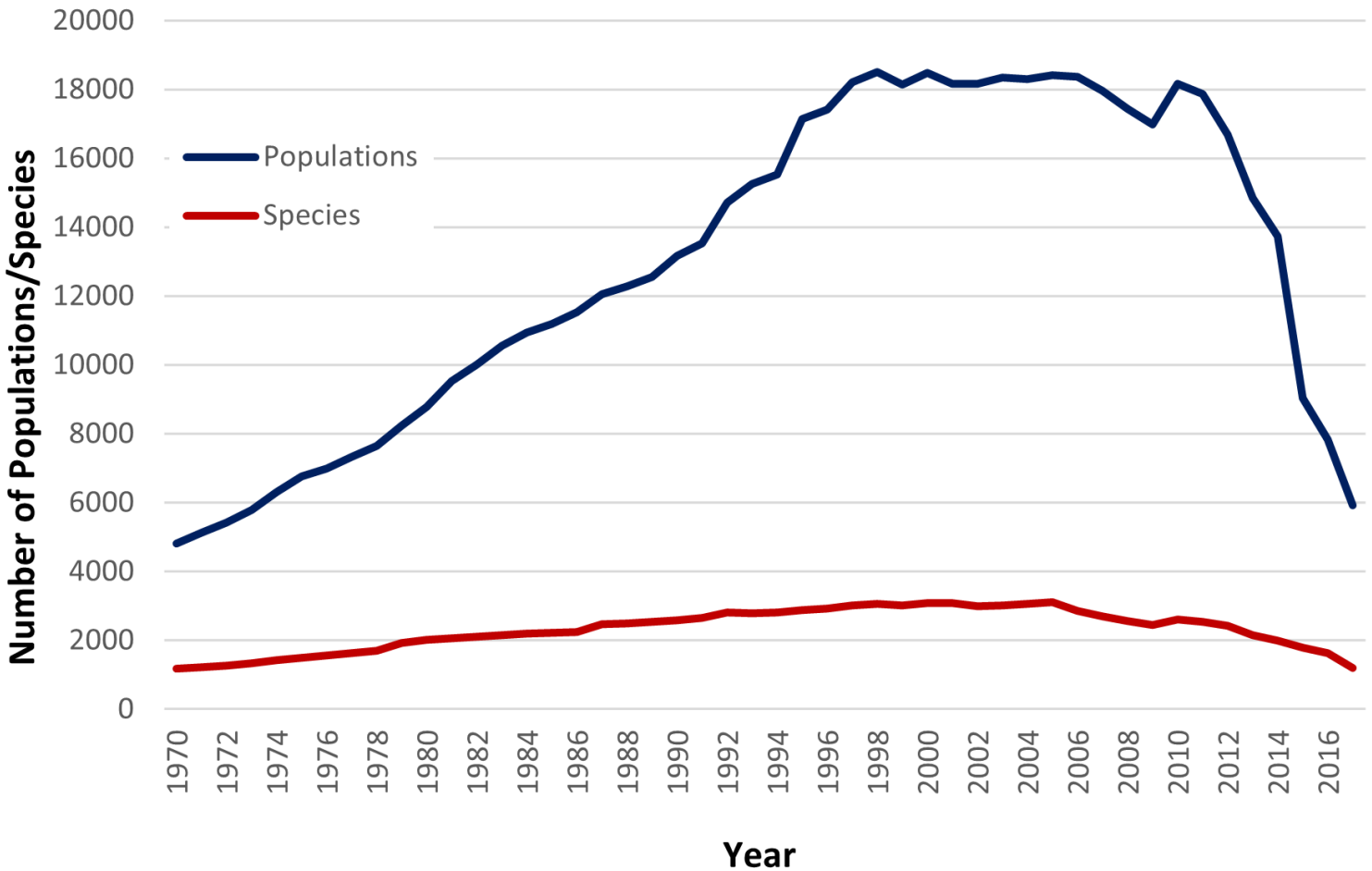
EUROPE (UNITED KINGDOM)
The common crane (*Grus grus*) has increased from zero breeding pairs in the UK in 1981 to 72 pairs in 2021[10].

EUROPE (CYPRUS)
The number of loggerhead turtles (*Caretta caretta*) nests along the coastline of Chrysochou Bay, Cyprus increased by 500% between 1999 and 2015[9].

AFRICA (RWANDA)
In the Virunga mountains, the number of mountain gorillas (*Gorilla beringei beringei*) has increased by 25% between 2010 and 2013[11].

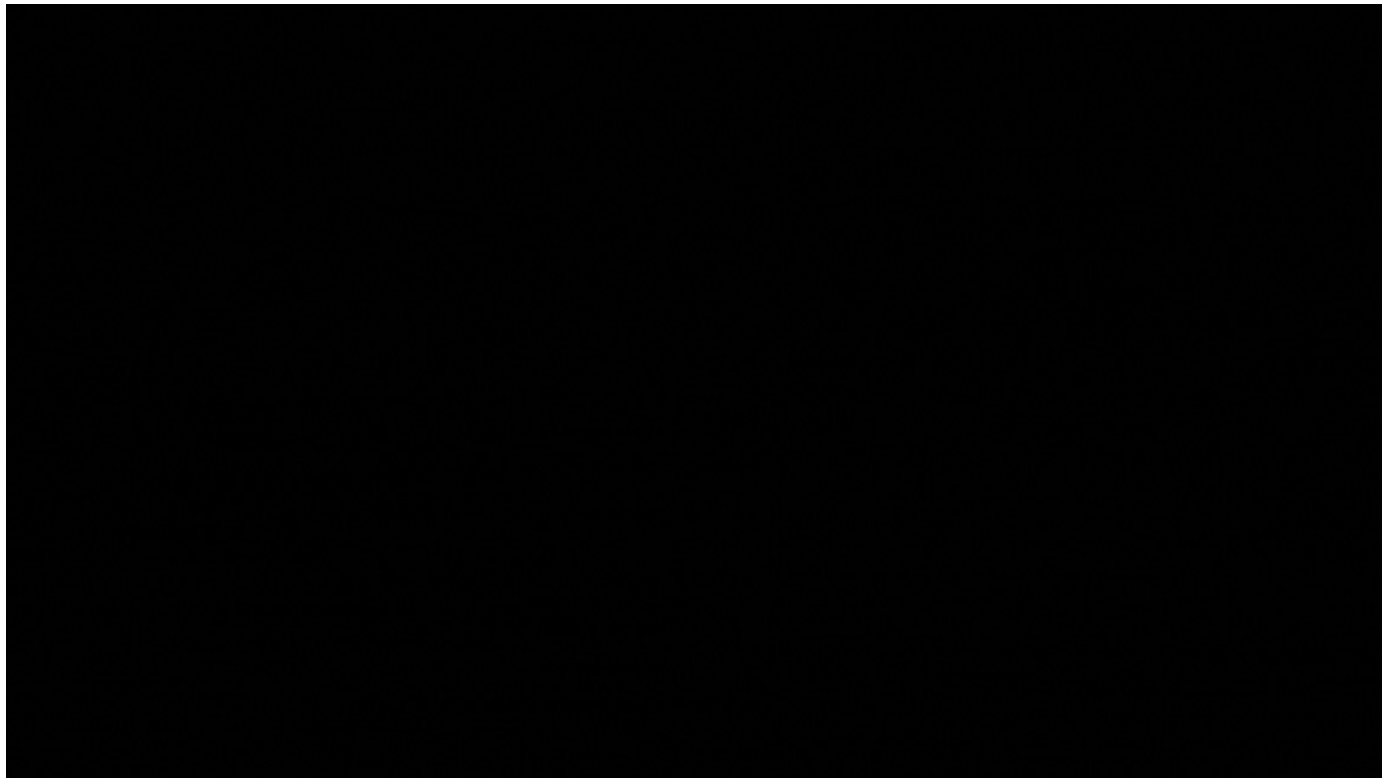
ASIA AND THE PACIFIC (AUSTRALIA)
The population of Australian sea-lions has declined by 64% between 1977 and 2019[8].

Biased temporal coverage



Different sources = different units, methodologies…

The units are… variable



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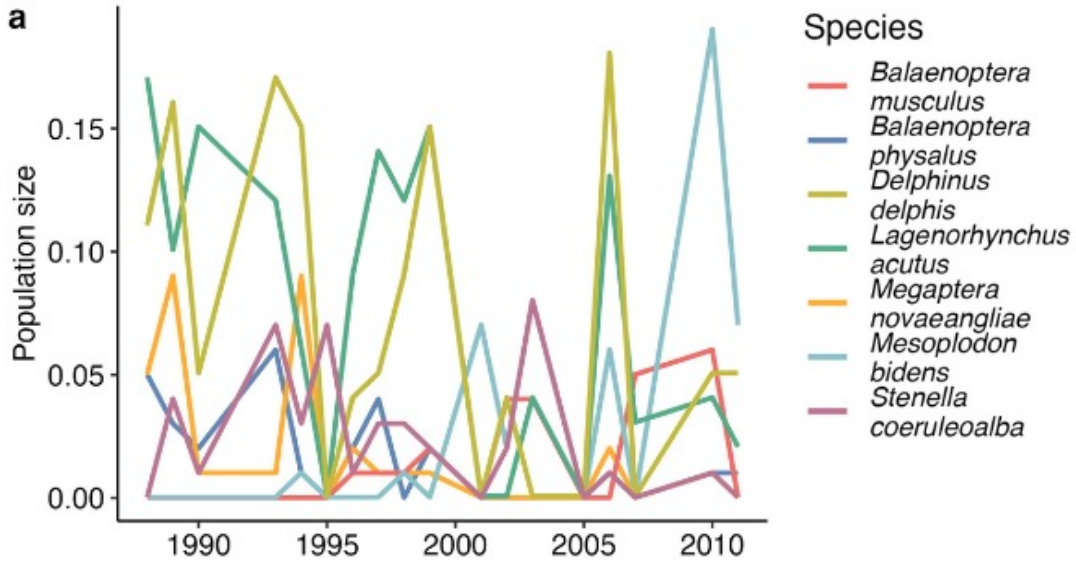
- Number of nightingales per 100000 birds ringed
- Tracks per 10km
- Millions of fish
- Billions of eggs

- Measuring changes in these units can lead to surprises



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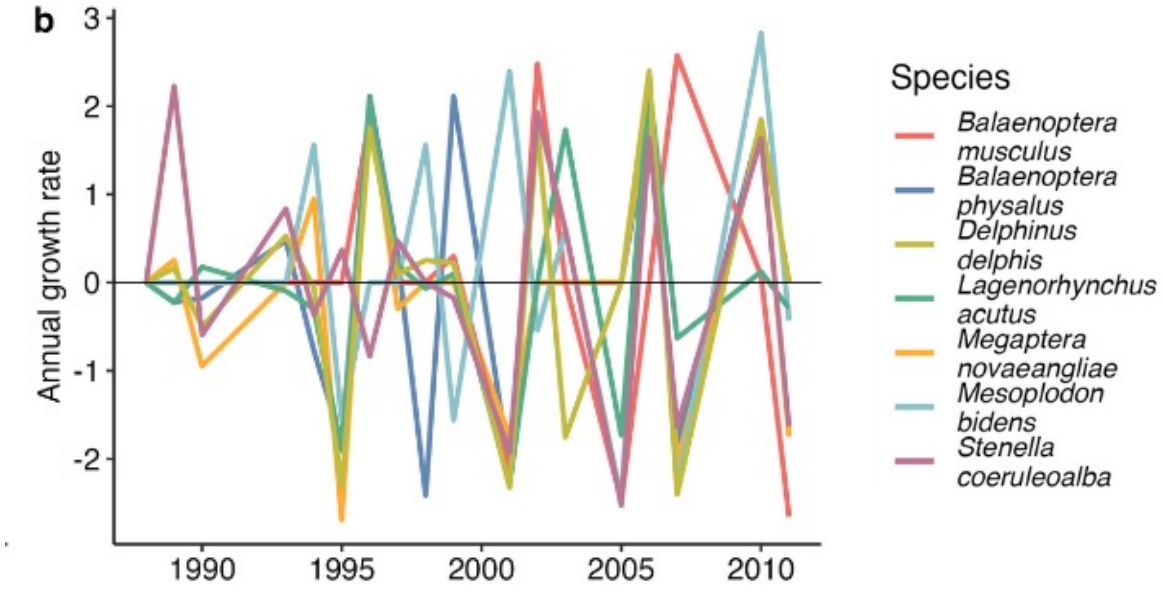


The database is constantly growing, and biases are slowly being addressed.

- Literature searches in more languages
- Monitoring programs are expanding and improving

In the meantime, the LPI weights trends to reduce the influence of geographic and taxonomic biases.

There is hope!

Ledger et al. (2023). npj.

The baseline

The baseline is not a real target,

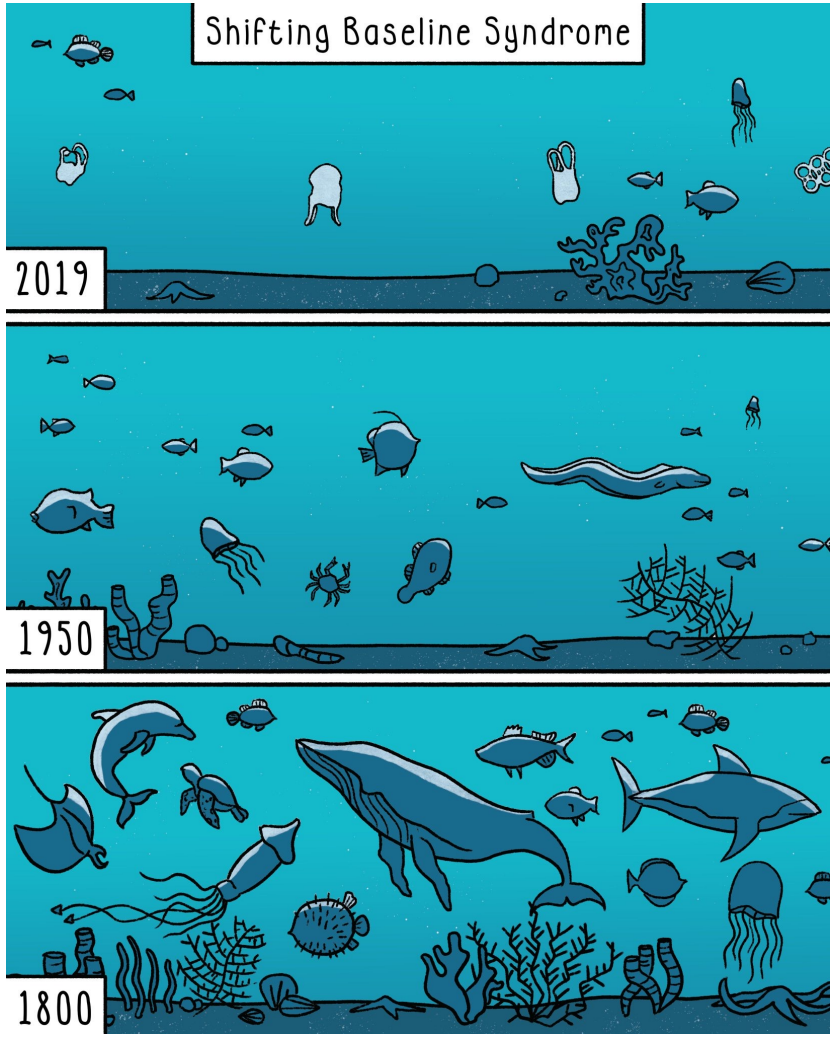
it’s a way to relativize change.

Shifting baseline syndrome

Baseline: The reference point from which we measure biodiversity change.

Baselines are **subjective**: the state of biodiversity that we aim to maintain/restore is only the best we know of.

Baselines **shift** as time goes on due to lack of past information or experience.



Cameron Shepherd

Matters arising

Shifting baselines and biodiversity success stories

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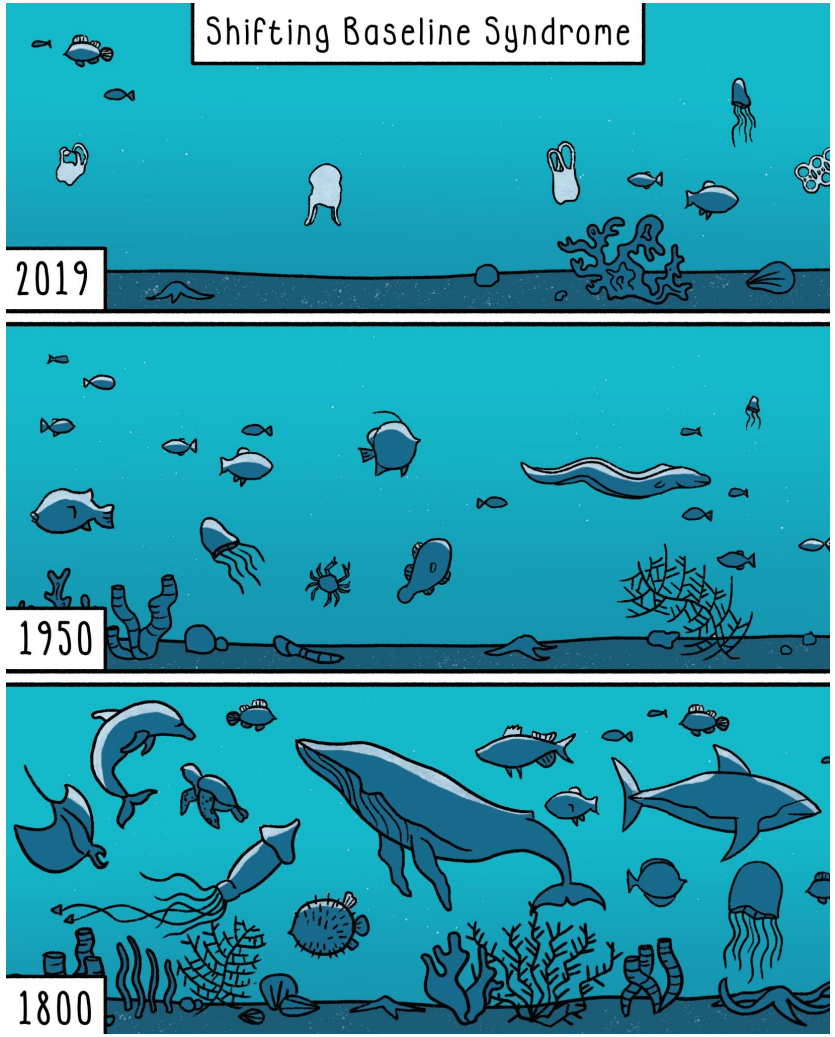
ARISING FROM B. Leung et al. *Nature* https://doi.org/10.1038/s41586-020-2920-6 (2020)

The LPI's baseline (1970) is **arbitrary**, and largely due to the available data.

Many declines happened ***before*** **1970**:

- Stable trends could mean that conservation have failed to improve trends.
- Some increasing populations are still much smaller than they once were.



Cameron Shepherd

Careful interpretation of the baseline

A global increase in the LPI would not mean that biodiversity has reached an objectively “good” target.

It just means that populations are, overall, doing “better”.

Mehrabi & Naidoo. (2021). Nature.

Careful interpretation of the baseline

Reflecting on what a baseline *means* is a good practice!

Mehrabi & Naidoo. (2021). Nature Ecol. Evol.

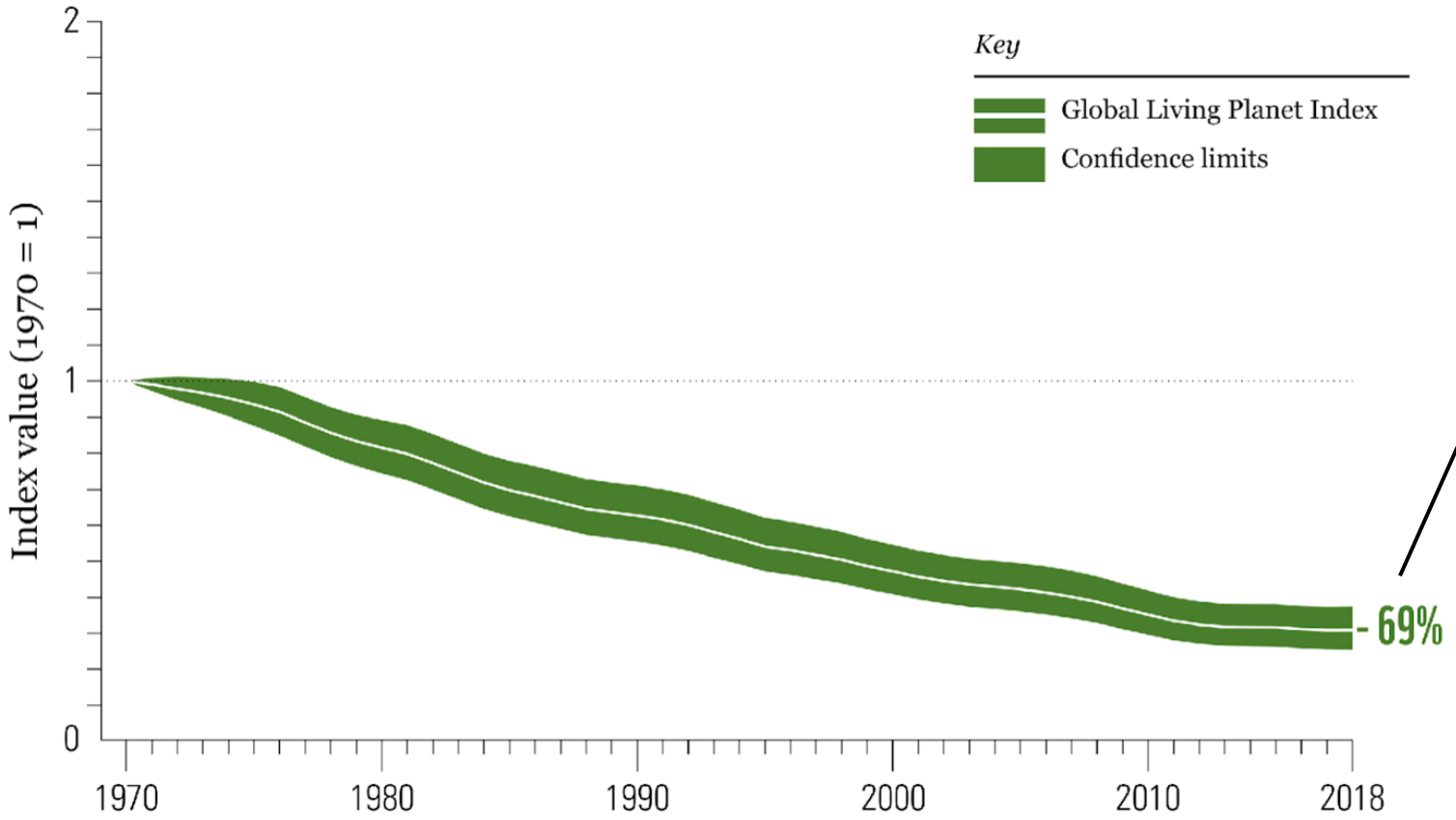
The average

Averages mask extreme trends,

but extremes are the most

important for conservation !

Living Planet Index: Global



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Brian Leung[1,2]✉, Anna L. Hargreaves[1], Dan A. Greenberg[3], Brian McGill[4,5], Maria Dornelas[6] & Robin Freeman[7]

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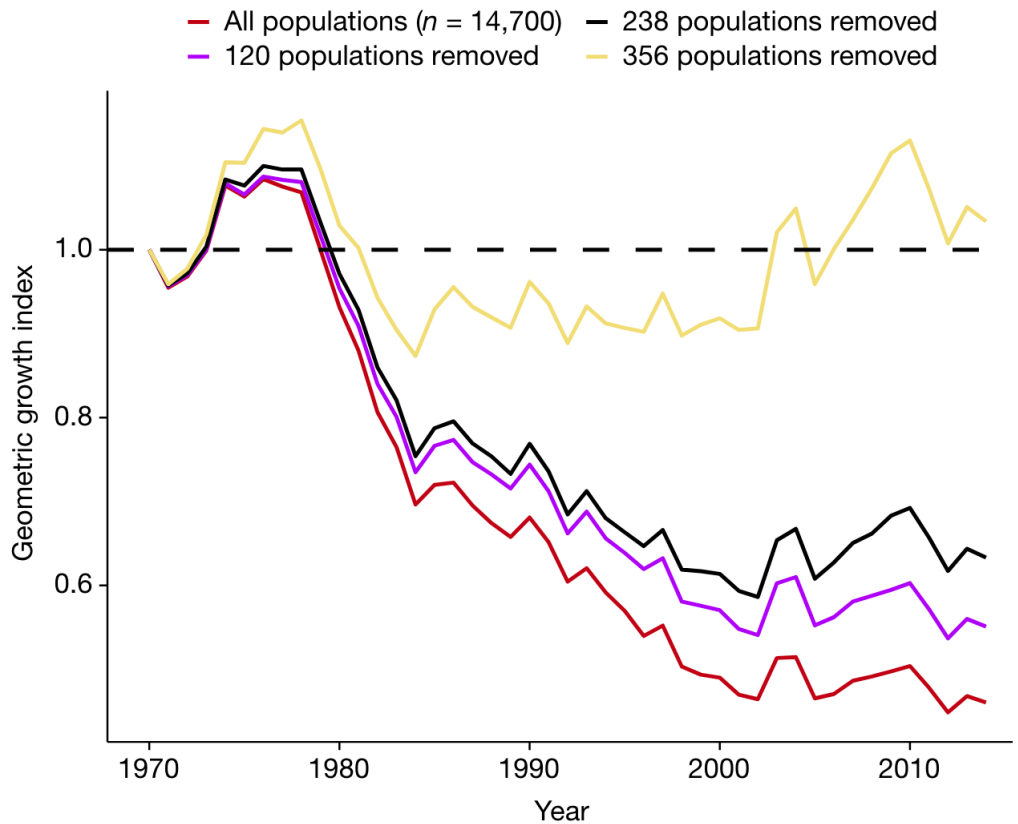

Leung *et al.* (2020). Nature.

Article

Clustered versus catastrophic global vertebrate declines

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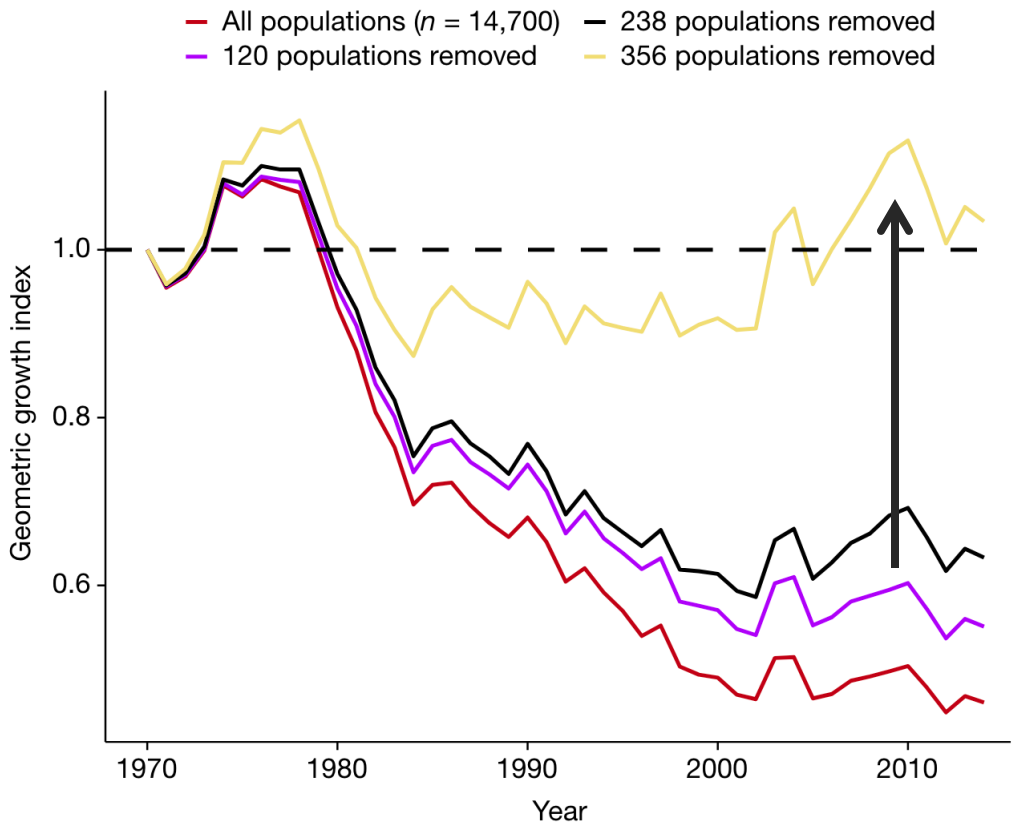

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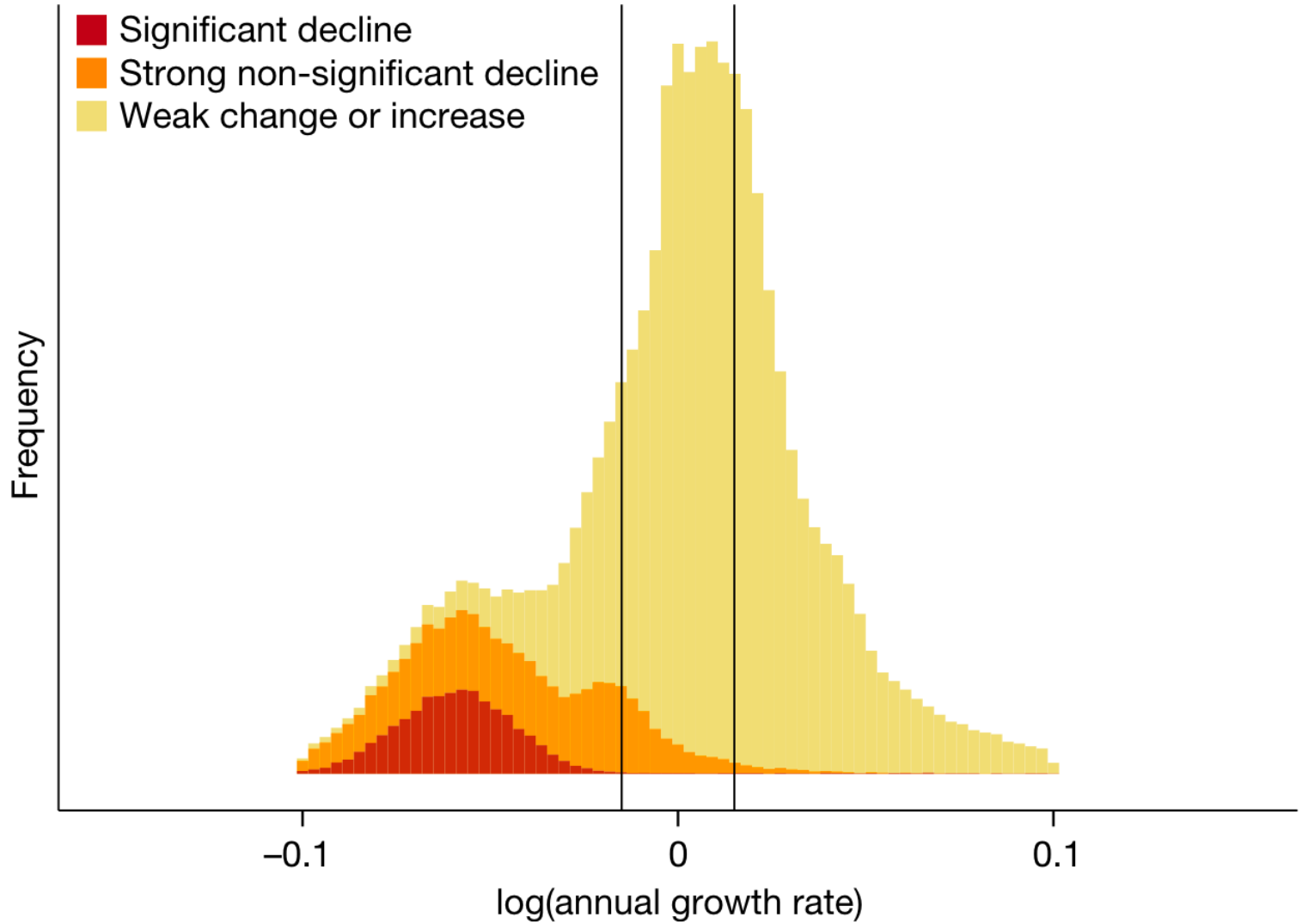

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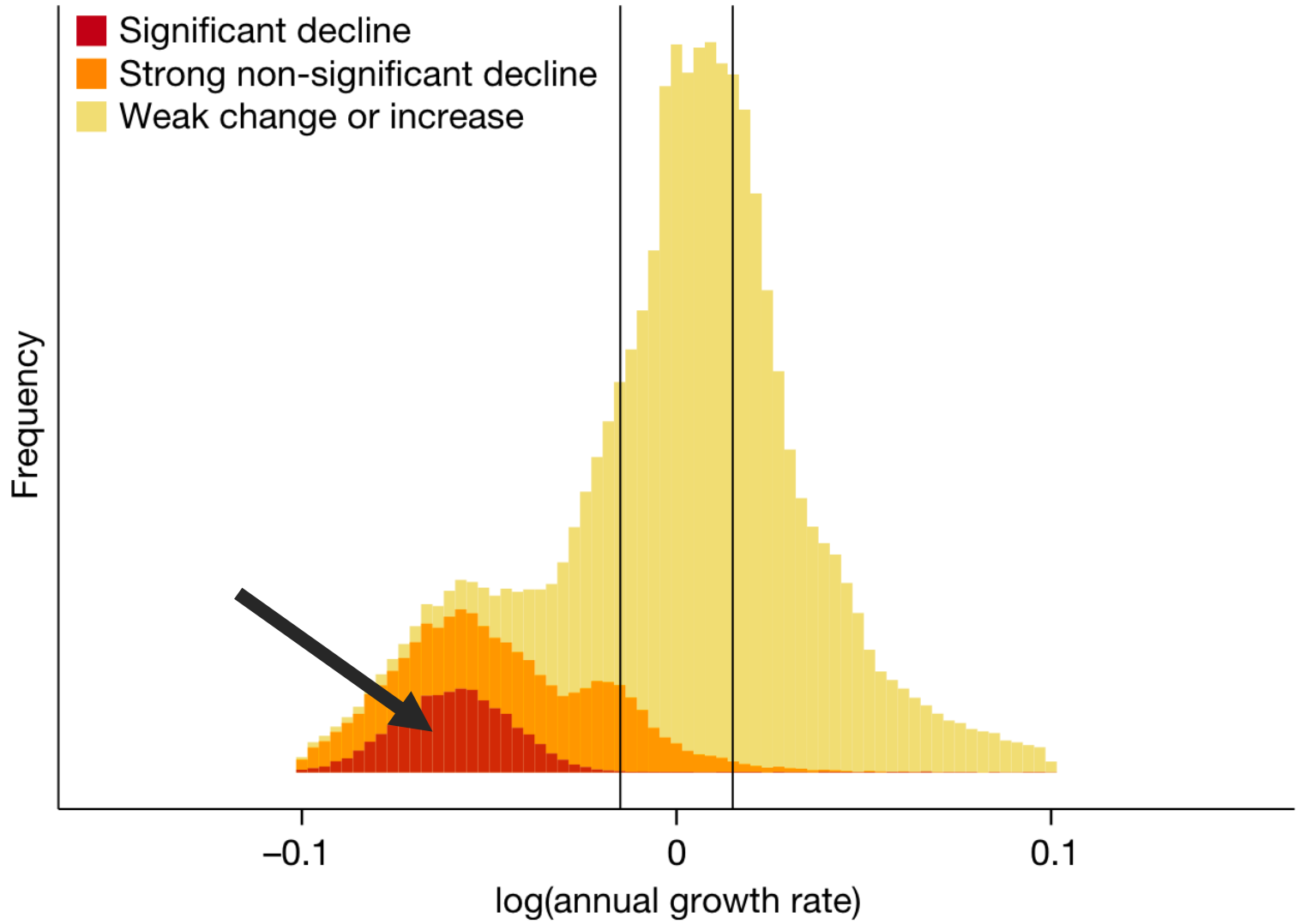


Leung *et al.* (2020). Nature.

Sensitivity to extremes =

the LPI doesn't reflect how ***most*** populations are changing...

When we account for extreme trends, we:

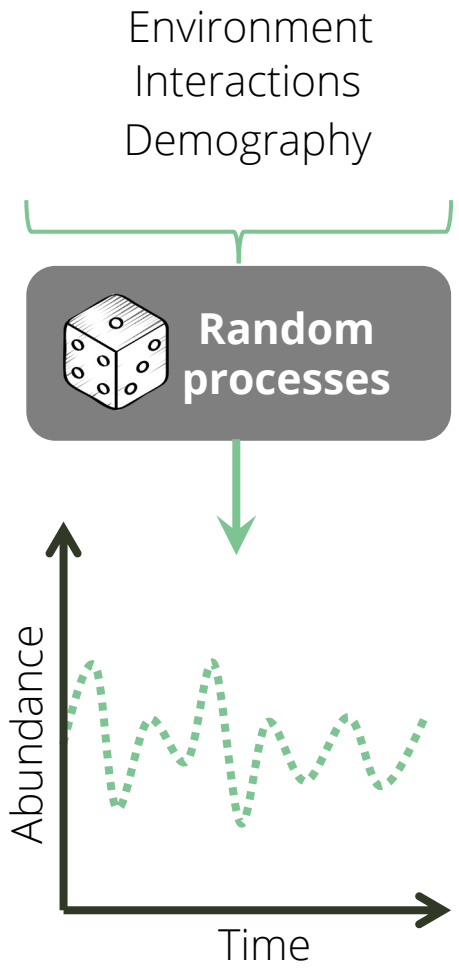
(1) get a more accurate average

(2) identify "extreme" populations that need more monitoring & action

Leung *et al.* (2020). Nature.

Variation
Part 1: Uncertainty intervals

Measurement generates variability in the data



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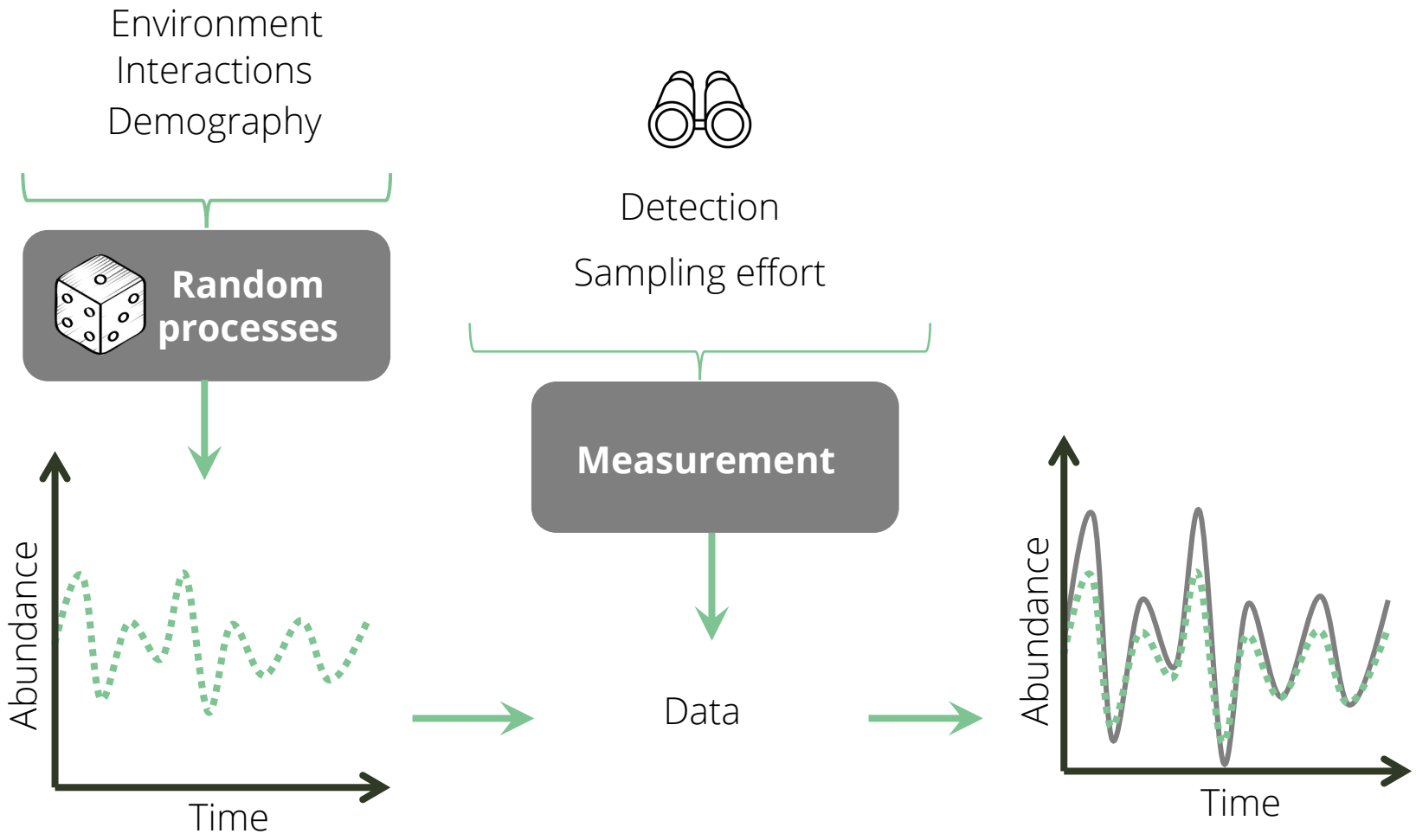
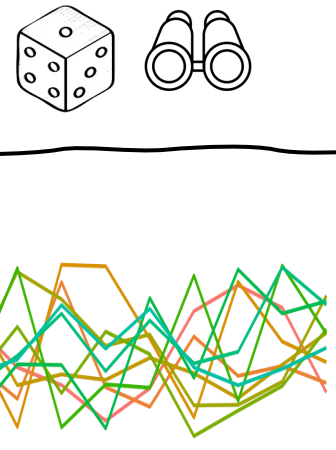
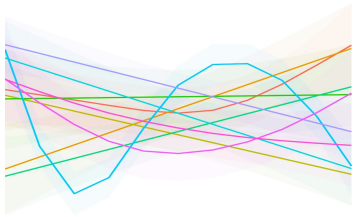
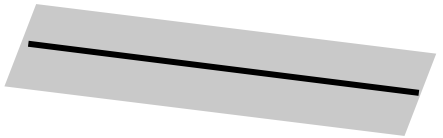


Where does this variability go?

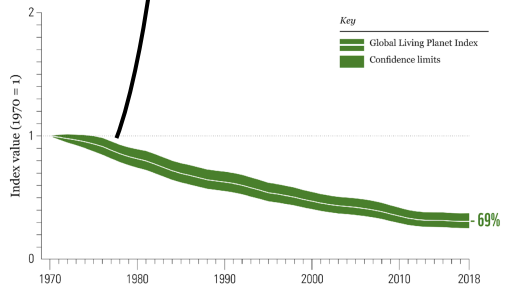
Variability





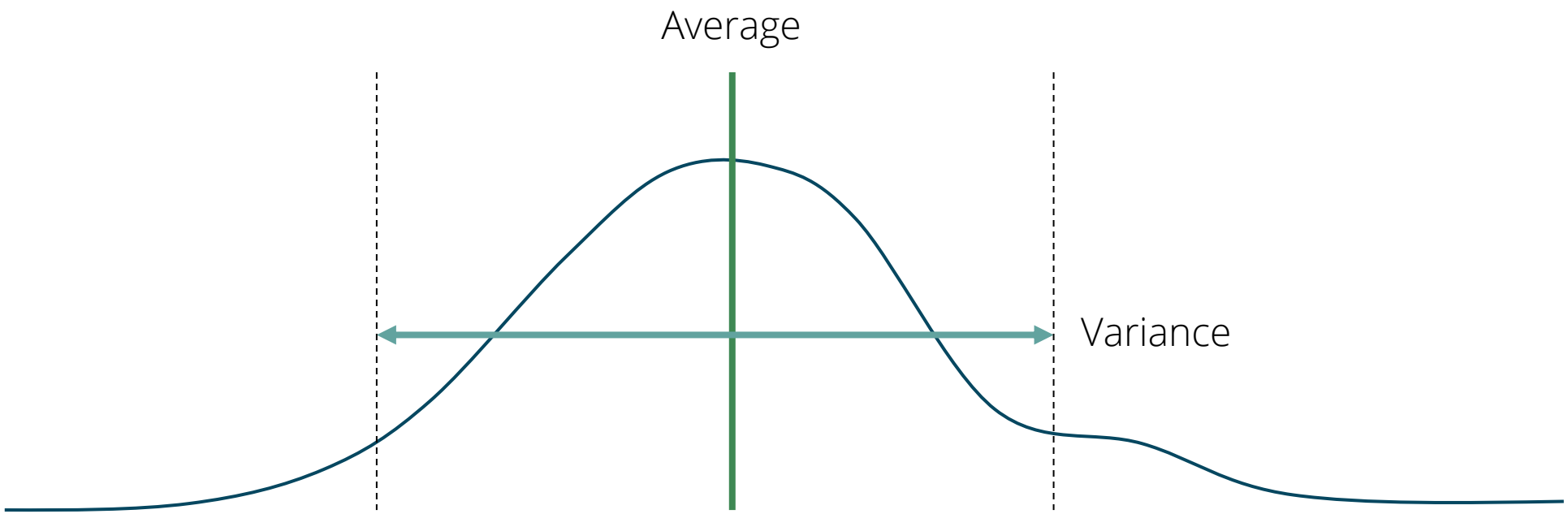


Variation across populations (after smoothing out the « noise »)



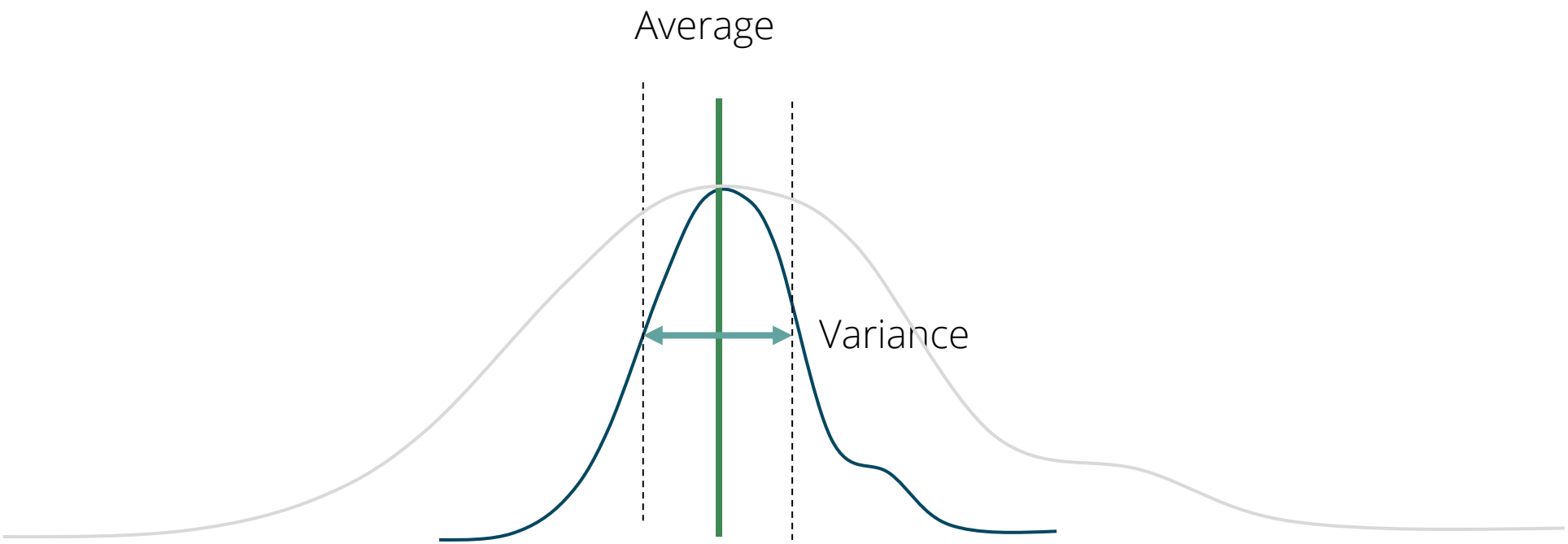
Abundance data → Smoothing models → Average trend → Living Planet Index

The variability in the raw data



Distribution of all population growth rates

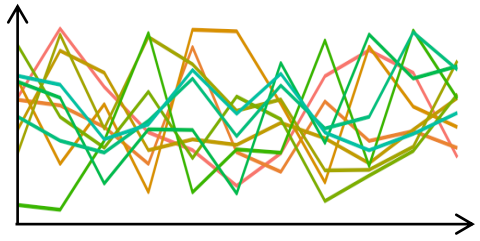
The variability left after smoothing



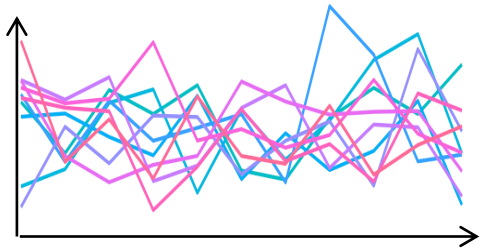
Distribution of all population growth rates

What happens when we keep the variation?

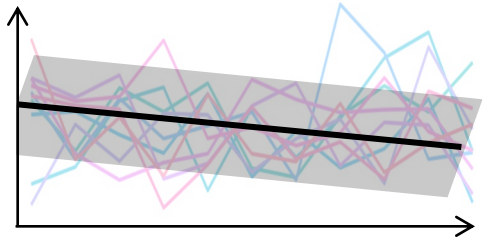
Abundance data



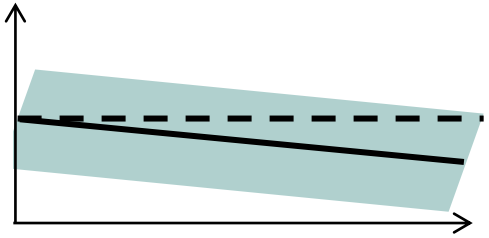
Growth rates
(not smoothed!)



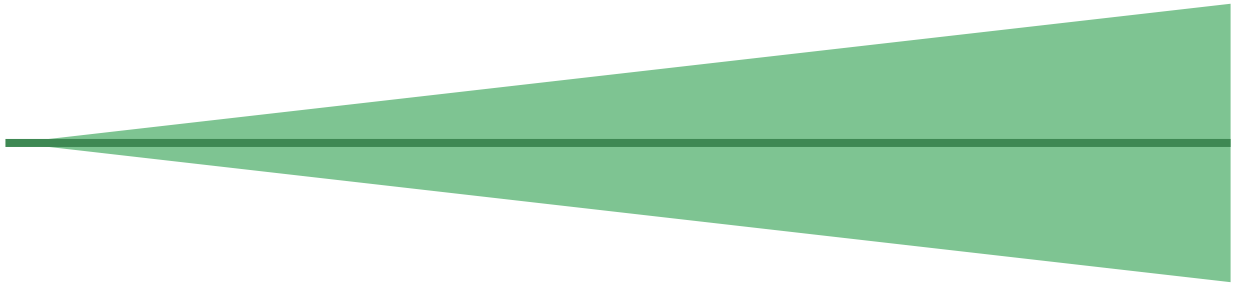
Average trend
(+ propagated variation)



Living Planet Index



The LPI’s confidence intervals always under-represents its variability



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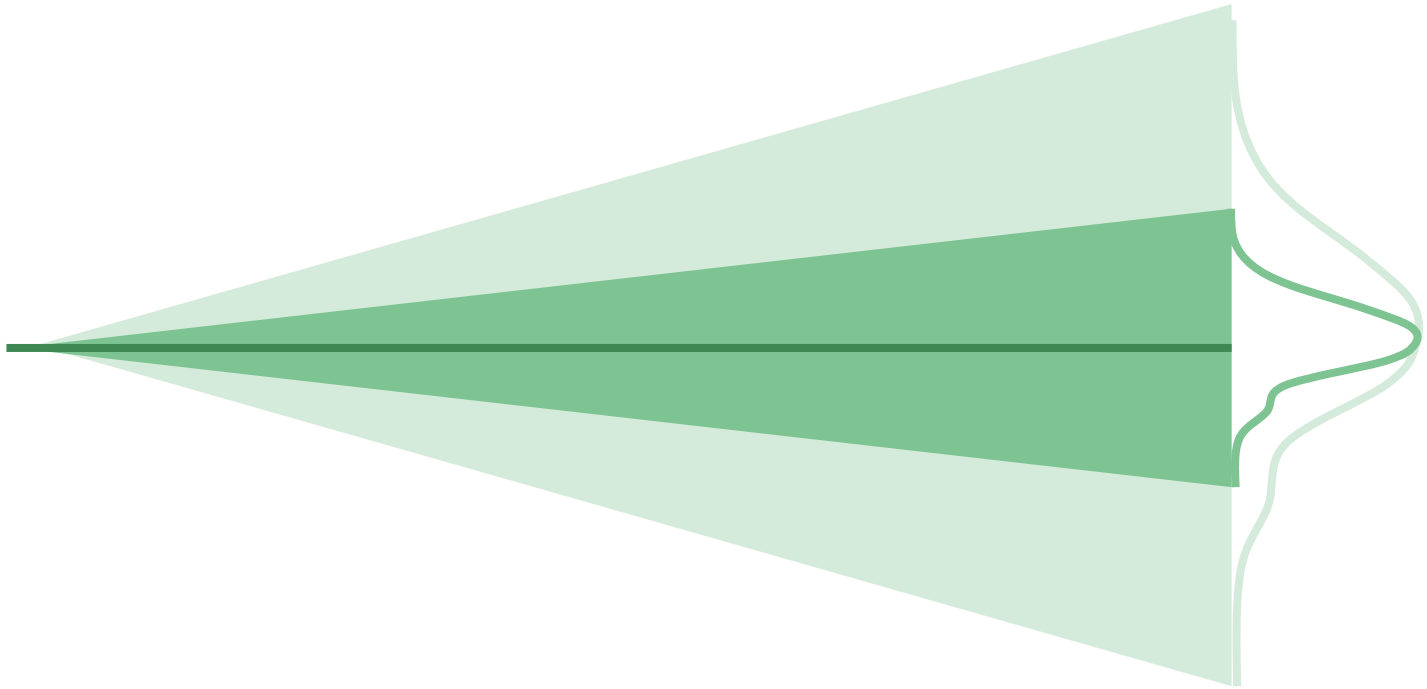
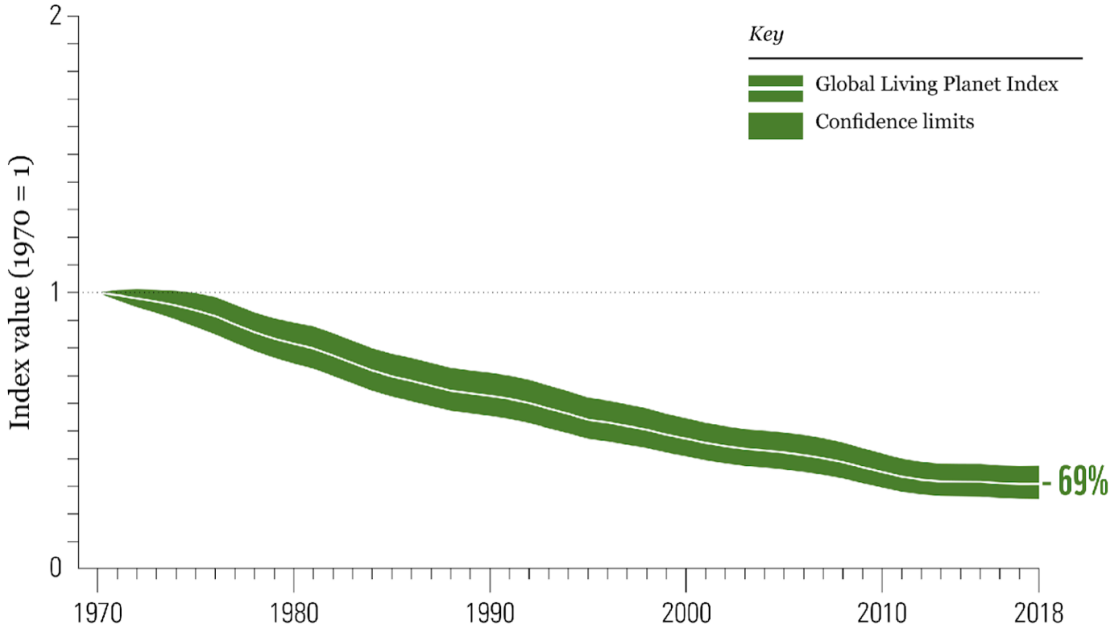


Hébert & Gravel. (2023). Ecology.

We know that the LPI is more uncertain than it appears!



Hébert & Gravel. (2023). Ecology.

Variation
Part 2: Correlated variation

Are we oversimplifying biodiversity changes?

Correlated variations

The LPI assumes that all species are varying independently to aggregate trends together without accounting for this variation.

But, species abundance variations can be correlated!

Species abundance variations are sometimes correlated

Article

Revealing uncertainty in the status of biodiversity change

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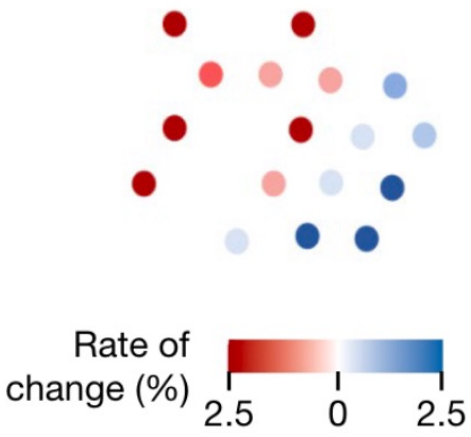
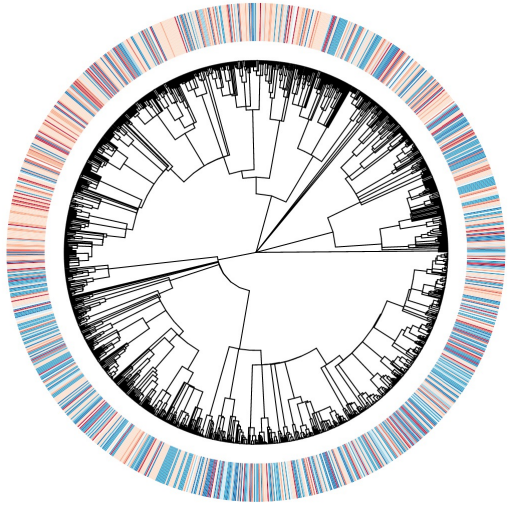
Species abundance variations are sometimes correlated

Trends are more similar between populations that are **nearby**.



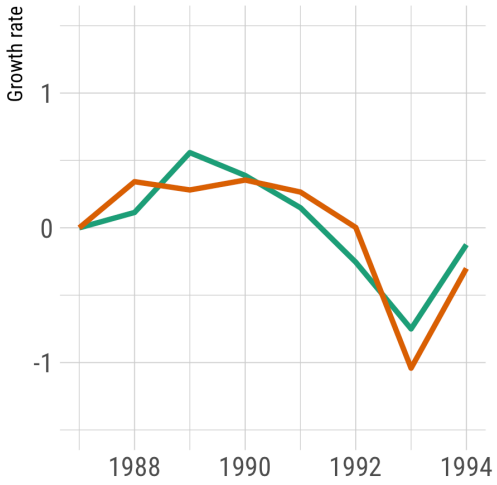
Johnson et al. (2024). Nature.

Closely-related species have more similar trends.

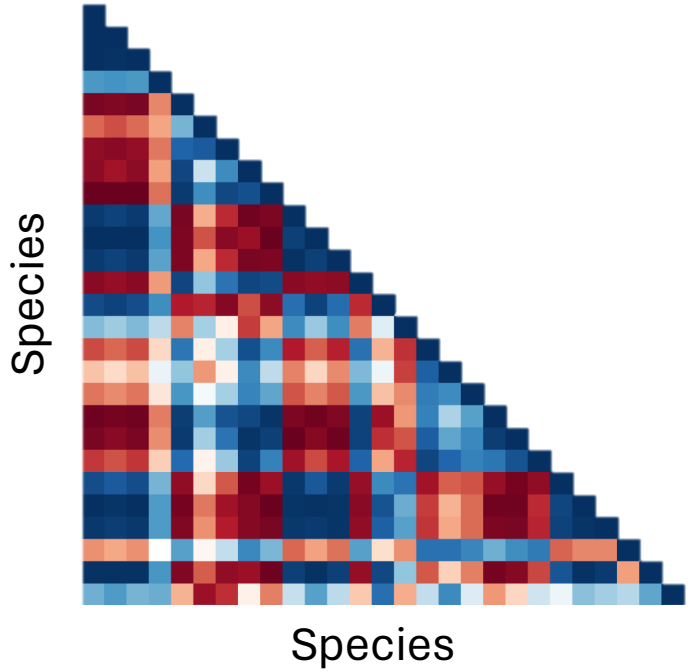


Johnson et al. (2024). Nature.

Interacting species are more likely to have correlated trends.



Correlations are important information, and we haven’t been using them!



Incorporating correlations into our models of population change is possible...

and makes more sense ecologically than aggregating population trends together as though they were random!

How to take these lemons and make lemonade...

Like any indicator, the LPI is imperfect but still useful

Population trends are one of the most sensitive metrics we have to capture biodiversity change.

Summarising data from many sources will always be messy and imperfect.

But, we know *many* of the LPI's limitations: we can correct and/or work around some of them.

Ultimately, we know more about the LPI than many other indicators!

4. How to make your own lemonade

Any indicator will be somewhat flawed…

Which flaws are reasonable to accept?
Which flaws are fatal?