We chose this approach over a meta-analysis of magnitude of published trends and their confidence intervals (Gurevitch et al. 2018), and over a statistical synthesis of the raw data behind each article (*e.g*. as in Blowes et al. 2019) for the following reasons: **1)** the metrics reviewed (n = 12) are conceptually heterogeneous and use hardly comparable units, **2)** datasets used in the articles are not always available, **3)** numerical values of trends are sometimes omitted and only displayed visually and, **4)** by simply counting different trends, we were able to include a higher number of studies than in a formal meta-analysis.

**Some text that we removed but could be useful**

Studying biodiversity can be confusing as there are many ways to measure it. The different metrics and indicators have diverse features, and one should consider which one is the most suited to its study. First, the type of biodiversity studied must be chosen (e.g. taxonomic, functional, phylogenetic diversity). Only then, one must choose the metric(s). Several standardized metrics have been created to assess their populations. Fraixedas et al. (2020) reviewed this wide spectrum of bird biodiversity indicators, without considerations to their link with spatial and temporal grains.

**What is lacking? (me brainstorming)**

* There have been numerous empirical studies that report systematic biodiversity trends (REF examples from the table).
* However, we currently lack a review/synthesis of all this published empirical literature.
* Is there an overall trend that holds across all of the different studies? Where do they come from? Which biodiversity metrics they use? Which scales do they cover.
* This review will, in part, show how the definition of temporal grain has still no consensus in the scientific literature.

**Composite and multi-species indicators.** The composite indicators are made to summarize several ecosystem information into one informative index. The most known ones are the Red List Index ([Stuart H. M. Butchart et al., 2007](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.1ci93xb); [Stuart H. M. Butchart et al., 2004](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.3whwml4); [S. h. m. Butchart et al., 2005](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.2xcytpi)), the Living Planet Index ([Loh et al., 2005](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.sqyw64)) or the Biodiversity Change Index ([Normander et al., 2012](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.25b2l0r)). In these composite indicators, metrics of great interest are the abundance-based or population-based metrics. As individuals react to stress or disturbances, the population trends reflect ecosystems health. The population decline that a species undergoes before going locally extinct is not captured by species-based metrics. Thus, population trends are usually efficient at assessing finer biodiversity declines. Although overall abundance is often hard to assess, the abundance of few indicator species can reflect processes in an entire ecosystem ([Richard D. Gregory et al., 2005](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.2grqrue)). This has led to a proposition of a family of metrics called the multi-species indicators (MSI, [Landres, Verner, and Thomas 1988](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.3ygebqi)). Examples are the farmland bird indicator, woodland bird indicator or Wildland Bird Indicator which summarizes the latter two ([Richard D. Gregory et al., 1999](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.41mghml); [Richard D. Gregory and Strien 2010](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.1hmsyys)). These metrics compute the geometric mean of abundance of few key species over time.

**Bird stuff.** Some of these functions, such as seed dispersal, control of pests, scavenging, or pollination, depend on birds and their diversity. Birds also have a significant esthetical value, with most countries having numerous iconic/charismatic species of conservation interest (<https://www.iucnredlist.org/>). Moreover, given their ability to quickly move between locations, their presence is also a good indicator for ecosystem health. Unfortunately, anthropogenic stressors like habitat loss, over-exploitation, pollution, or introduction of invasive species are a threat to birds and their biodiversity ([Donald, Green, and Heath 2001](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.49x2ik5); [Frédéric Jiguet et al., 2010](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.46r0co2)), with concerns that they could face a sixth mass extinction ([Barnosky et al., 2011](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.z337ya)).

**Metric heterogeneity.** In contrast to macroecology, applied ecology has offered multiparametric indices that aim to reflect multiple components of an ecosystem, the so-called *composite indicators*. For birds, these indices have been widely used (see review by [Fraixedas et al., 2020](https://docs.google.com/document/d/1iLaKCgOToG2z3n7-jCZhLGTiK-xjQKeRlAqjQfd_1bQ/edit#bookmark=id.32hioqz)) and have proven to be effective for conservation policies. Some of these metrics either reduce (*e.g.* MSI which use a limited number of species) or increase (*e.g.* the Biodiversity change index which takes into account habitat features) the complexity of the metric. In order to study the link between biodiversity trends and spatio-temporal grains, we need to use the common macroecology metrics, such as species richness, diversity or abundance indices.

We found longest temporal lags in studies with large spatial extent. This is because data used in the selected articles are mainly structured data, *i.e.* data following a well established sampling plan. This type of survey is sparse since it needs resources and organization. Increasing the spatial extent thus increases both the temporal extent and the time to sample all the sampling units. This explains this positive correlation between spatial extent and temporal lag. This limitation can be overcome thanks to citizen science data, which have increasingly been used (*e.g.* Bowler et al., 2021; Isaac et al., 2014, 2020). The opportunistic nature of these data allows for short census times, even over a large area. These data, with high temporal grain resolution for large spatial scales, could in future be used to explore in more details the temporal scaling of biodiversity trends, especially for low temporal lags.