Literature review

PhD candidate: François Leroy

Programme: Environmental Earth Sciences

Department: Spatial Sciences

"Mapping biodiversity changes across spatio-temporal scales"

Advisor: doc. Ing. Petra Šímová, Ph.D.
Consultant: Mgr. Petr Keil, PhD
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Contents

Outline

Literature review about the link between biodiversity facets trends and spatial/temporal scales.

The idea is to take every paper that talk about biodiversity trends (so far using just the species richness seems already a lot of paper) and to list **1)** which biodiversity metric they use **2)** which taxon/taxa they use, **3)** the spatial scale, **4)** the temporal scale and **5)** what is the dynamic (does the biodiversity metric increase/decrease/doesn't change over time/unclear).

Make a table of all these papers and `group_by(taxa) %>% order_by(spatial_scale | temporal_scale)`. Then see if for each taxa we can find a trend (a bit like in Chase *et al.* 2019 Oikos paper | Jarzyna *et al.* 2015 but here I am not making the analysis, just taking the analysis from papers). Best example found so far: Hill & Hamer 2004

I am using the "Advanced Research" tab of Web of Science which allows me skim through the entire literature using a convenient syntax. For instance:

```
AB = ((biodiversity OR species richness OR diversity) AND
(temporal trend* OR dynamic*) AND
(bird* OR avia*))
```

And

```
AB = ((biodiversity change index)  AND (bird*  OR avia*)  AND trend*)
```

And

```
AB = ((species richness) AND (bird* OR avia*) AND trend*)
```

And

```
ALL=(birds AND species richness AND temporal trend)
```

Dashboard

Reference paper

- 05/07/2021: research wos made with the literature review filter for the first query (stopped at #13) and created the second query (stopped at #2)
- 07/07/2021: questions to Petr: **1)** can the geometric mean of relative abundance + the weighted goodness of fit be used as biodiversity trend index, **2)** can the Farmland Bird Indicator (FBI) be used as biodiversity trend (for me it is more biodiversity health, Chiron et al 2013) **3)** what about the Red List Index trend? **4)** what about Multispecies population indexes?
- 08/07/2021: stopped at the article 41 for research #2.
- 12/08/2021: stopped at article 4 for research #4
- 13/08/2021: stopped at article 8 for research #4
- 17/08/2021: stopped at article 15 for research #4
- 18/08/2021: stopped at article 30 for research #4
- 19/08/2021: stopped at article 46 for research #4
- 20/08/2021: stopped at article 64 for research #4
- 01/09/2021: verifying spatial scales –> stopped at Dittrich 2019
- 02/09/2021: **Question 1:** for the FBI/WBI…*BI indexes, usually they use a GLM/GAM to predict the abundance over the entire spatial extent and then compute the metric. Basically, those metrics are geometric means of predicted species abundances. Which spatial scale to use: the spatial unit of the prediction (i.e. the plot), or the entire area predicted? (Imo, the second option is correct). **Question 2:** same question for the Geometric mean but I am realizing while writing this question that *BI are kind of similar to geometric means so answering the first question will answer this one.

Papers that are driving me mad: Doxa et al., Jiguet et al., and Chiron et al., Eglington and Pearce-Higgins

1. Introduction

Human life quality is intrinsically linked to ecosystems state that he is living in. Indeed, ecosystems services extend in a large spectrum of mechanisms including nutrient cycle, food production, or climate and water cycle regulation (Pereira et al.). Some of those ecosystem functions are managed by bird biodiversity such as seed dispersal, controls pests or pollinate plant. Unfortunately, anthropogenic stressors like habitat loss, over exploitation, pollution or introduction of invasive species could lead biodiversity to its sixth mass extinction (Barnosky et al.).

Biodiversity erosion is now known from everyone and political decisions has been stated in order to limit it (*e.g.* The Convention on Biological Diversity, 2010, 2002). However, these objectives have been so far not reached due mainly to our confusion and misunderstanding about biodiversity dynamic and how to determine it.

As a matter of fact, studying biodiversity can be confusing, especially because several choices must be done. Firstly, the level at which you are looking at the biodiversity must be chosen (*e.g.* species, functional, phylogenetic diversity). Secondly, one must decide which metric is the most appropriate for his study. There are many facets of biodiversity that can be measured by different metrics depending on the objective of your study. Measures of static biodiversity are commonly used such as species richness or α diversity (*i.e.* number of species, Whittaker, b), the Shannon index (Shannon) ,the Simpson index (Simpson) or the Hill number (Hill). The later three biodiversity indexes take into account the relative abundances of the species and can be considered as the *quality* of the biodiversity. On an other hand, the spatial and temporal β diversity will measure the species turnover and can be measured thanks to Whittaker's (Whittaker, a), Sørensen's (Sørensen) or Jaccard's (Jaccard) dissimilarity indexes (*e.g.* Keil et al.).

However, overall biodiversity (*i.e.* taking into account species of every taxa) may not be relevant for one's case study. Thus, several multi-species indicators have also been created, taking into account the abundances of indicator species giving information on the ecosystem health. The most known ones are the Red List Index (Butchart et al., b,a,c) or the Biodiversity Change Index (Normander et al.).

Using all the metrics cited above, we now know that the loss of global biodiversity is unprecedented. However, current scientific literature has also shown that temporal trends in local changes of biodiversity can be opposite to trends at larger scales (*e.g.* Chase et al.). Thus, current changes in biodiversity is far more complex than a simple global decrease: most of the ecosystems undergo alterations of their communities with changes in species composition (Blowes et al.; Dornelas et al.). Wonders persist about how the trend of these different metrics of biodiversity are link to the spatial and temporal scales used when measured.

In order to investigate this link between spatial scales and biodiversity metrics, birds is a relevant taxon. Thanks to the many ornithological monitoring and surveys, we now have a large number of long, high-quality time series on bird populations (Bejček and Stastný). Birds are easy to observe, easy to identify and thus many volunteers are motivated to conduct standardized sampling. Given their ability to change quickly of locations, their presence is also a good indicator for ecosystem health and thus several standardized metrics have been created to assess their populations. For instance, the geometric mean of relative abundances or the goodness-of-fit statistic (Studeny et al.) are some of the baseline. Other multi-species indicators have also been created specifically for birds, such as the Farmland Bird Indicator (Gregory et al., a), the Forest Bird Indicator (Gregory et al., b) or the Wild Bird Indicator (Gregory and Strien).

Here, I propose to review articles assessing the temporal trends of different avian biodiversity metrics and to look at which spatial scales these studies have been done. Summarizing the trends of these qualitative and/or quantitative avian biodiversity indexes along with their spatial and temporal scales will help to see more clearly how the trends of biodiversity are linked to spatio-temporal scales. It is also important to demonstrate that the information about the sampling plan (*i.e.* spatial scale, time span, temporal scales etc) is not systematically indicated in the scientific literature and can bring confusion to the analysis and comparisons of their trends. I believe that this review can help to have a better overview of the current knowledge on the trend of biodiversity metrics of bird populations.

2. Materials and Methods

For this review, articles of interest were the ones assessing temporal trends of the most common indicators (*i.e.* metrics) of avian biodiversity and specifying spatial and temporal scales. For this, I used the *"advanced search"* tool of the ISI Web of Science Core collection database with these four following queries:

1. `AB = ((biodiversity OR species richness OR diversity) AND (temporal trend* OR dynamic*) AND (bird* OR avia*))` which resulted in 1346 references.

2. `AB = ((biodiversity change index) AND (bird* OR avia*) AND trend*)` which resulted in 60 references.

3. `AB = ((species richness) AND (bird* OR avia*) AND trend*)` which resulted in 313 references.

4. `ALL=(birds AND species richness AND temporal trend)` which resulted in 88 references.

For each query, the title and abstract of the articles were reviewed. When the temporal trend was explicitly specified (either visually or literally), the material and method part was read in order to collect the *spatial grain* of the trend (*i.e.* the area at which the trend is assessed), its *temporal grain* (*i.e.* the time span at which data have been gathered on the field), the *spatial extent* (*i.e.* the entire area at which the study applies), the *temporal extent* and the *beginning and ending years* of the study as well as the *general trend* of the metric (Tab. 2.1).

Concerning the trend assessment, some papers contained the *p-value* or directly specified the significant trend of the metric. However, a portion of papers gives only visual representations of the trend. For those, the standard error was used when displayed. For the very few only giving the trend, the rule of thumb was applied. Information can be found in the column *Note* of the Tab. 2.2 of the supplementary material. Moreover, the final trend retained (*i.e.* either *Increase*, *Stable* or *Decrease*) doesn't reflect all the fluctuations of the metric through time but rather the difference between the starting and ending points.

Moreover, Pilotto et al. conducted a meta-analysis in which they computed and summarized the trend of four biodiversity metrics (namely, species richness, species diversity, abundance and temporal turnover). Some of them were concerning bird communities. For those latter, I used their code and data on the github repository of their paper in order to compute the trends of these four metrics for the bird datasets.

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness,

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Barnagaud et al.	SR	0.500	1.000	9834000.00	41	1970-2011	USA	Increase
Barnagaud et al.	Abundance	0.500	1.000	9834000.00	41	1970-2011	USA	Decrease
Barnagaud et al.	Evenness	0.500	1.000	9834000.00	41	1970-2011	USA	Increase
Barnagaud et al.	Functional richness	0.500	1.000	9834000.00	41	1970-2011	USA	Increase
Barnagaud et al.	Functional dispersion	0.500	1.000	9834000.00	41	1970-2011	USA	Stable
Barnagaud et al.	Functional evenness	0.500	1.000	9834000.00	41	1970-2011	USA	Increase
Roels et al.	SR	0.040	1.000	0.04	5	NA	Panama	Increase
Roels et al.	Bird activity	0.040	1.000	0.04	5	NA	Panama	Increase
Wretenberg et al.	SR	0.030	1.000	1800.00	11	1994-2004	Sweden	Decrease
Ram et al.	SR	1.600	1.000	350000.00	18	1998-2015	Sweden	Increase
Ram et al.	SR	1.600	1.000	350000.00	18	1998-2015	Sweden	Stable
Ram et al.	SR	1.600	1.000	350000.00	18	1998-2015	Sweden	Increase
Ram et al.	Multi-species indicator	1.600	1.000	350000.00	18	1998-2015	Sweden	Increase
Ram et al.	Multi-species indicator	1.600	1.000	350000.00	18	1998-2015	Sweden	Increase
Harrison et al. (b)	Geometric mean	10000.000	0.500	NA	20	1994-2013	UK	Increase

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Harrison et al. (b)	GoF (λ = -1)	10000.000	0.500	NA	20	1994-2013	UK	Stable
Harrison et al. (b)	GoF (λ = -2)	10000.000	0.500	NA	20	1994-2013	UK	Stable
Doxa et al.	FBI	4.000	1.000	643801.00	8	2001-2008	France	Increase
Doxa et al.	FBI	4.000	1.000	643801.00	8	2001-2008	France	Stable
Doxa et al.	FBI	4.000	1.000	643801.00	8	2001-2008	France	Stable
Arnold et al.	SR	0.020	1.000	1000.00	100	NA	Trinidad	Stable
Arnold et al.	Shannon	0.020	1.000	1000.00	100	NA	Trinidad	Stable
Arnold et al.	Simpson	0.020	1.000	1000.00	100	NA	Trinidad	Stable
Xu et al.	SR	6.560	1.000	6.56	12	2002-2013	China	Decrease
Jiguet et al.	GBI	4.000	1.000	643801.00	22	1989-2009	France	Increase
Jiguet et al.	WBI	4.000	1.000	643801.00	22	1989-2009	France	Increase
Jiguet et al.	UBI	4.000	1.000	643801.00	22	1989-2009	France	Increase
Jiguet et al.	FBI	4.000	1.000	643801.00	22	1989-2009	France	Increase
Jiguet et al.	EU bird directive	4.000	1.000	643801.00	22	1989-2009	France	Increase
Jiguet et al.	RLI (Red list Index)	NA	1.000	10180000.00	22	1989-2009	France	Decrease
Keten	SR	1.700	1.000	1.70	11	2006-2016	Turkey	Stable
Davey et al.	Simpson	1.000	1.000	242495.00	13	1994-2006	UK	Increase

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Davey et al.	SR	1.000	1.000	242495.00	13	1994-2006	UK	Increase
Davey et al.	Evenness	1.000	1.000	242495.00	13	1994-2006	UK	Increase
Christian et al.	SR	15.400	NA	15.40	209	1898-2006	France	Increase
Dittrich et al.	SR	0.053	0.330	53.00	3	2010-2012	Spain	Increase
Dittrich et al.	SR	0.053	1.000	53.00	3	2010-2012	Spain	Increase
Dittrich et al.	SR	0.083	0.330	53.00	3	2012-2014	UK	Stable
Dittrich et al.	SR	0.083	1.000	53.00	3	2012-2014	UK	Stable
Sirami and Monadjem	SR	0.380	1.000	430.00	21	1998-2018	Swaziland	Decrease
García-Navas et al.	Spatial beta-diversity	267.000	1.000	267.00	20	1999-2018	Switzerland	Decrease
Ellis et al.	SR	0.160	1.000	NA	21	1994-2014	Oregon, USA	Stable
Ellis et al.	SR	0.160	1.000	NA	21	1994-2014	Oregon, USA	Stable
Ellis et al.	SR	0.160	1.000	NA	21	1994-2014	Oregon, USA	Increase
Ellis et al.	SR	0.480	1.000	NA	21	1994-2014	Oregon, USA	Stable
Ellis et al.	Shannon	0.160	1.000	NA	21	1994-2014	Oregon, USA	Increase
Ellis et al.	Shannon	0.160	1.000	NA	21	1994-2014	Oregon, USA	Decrease
Ellis et al.	Shannon	0.160	1.000	NA	21	1994-2014	Oregon, USA	Increase
Ellis et al.	Shannon	0.480	1.000	NA	21	1994-2014	Oregon, USA	Increase
Ellis et al.	Simpson	0.160	1.000	NA	21	1994-2014	Oregon, USA	Increase
Ellis et al.	Simpson	0.160	1.000	NA	21	1994-2014	Oregon, USA	Decrease

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km^2)	Temporal grain (year)	Spatial extent (Km^2)	Temporal extent (year)	Years	Country	Trend
Ellis et al.	Simpson	0.160	1.000	NA	21	1994-2014	Oregon, USA	Increase
Ellis et al.	Simpson	0.480	1.000	NA	21	1994-2014	Oregon, USA	Decrease
Sicurella et al.	Occurence (%)	17370.300	1.000	23844.00	22	1992-2013	Lombardy, Italy	Stable
Sicurella et al.	Occurence (%)	1403.900	1.000	23844.00	22	1992-2013	Lombardy, Italy	Stable
Sicurella et al.	Occurence (%)	6461.900	1.000	23844.00	22	1992-2013	Lombardy, Italy	Increase
Nally	SR	0.490	0.003	10.00	3	1994-1996	Australia	Increase
Latta et al.	SR	1.180	2.000	NA	14	1994-2007	Ecuador	Decrease
Latta et al.	SR	1.180	2.000	NA	14	1994-2007	Ecuador	Decrease
Scarton	SR	0.550	2.000	0.55	25	1990-2014	Lagoon of Venice, Italy	Increase
Scarton	Shannon	0.550	2.000	0.55	25	1990-2014	Lagoon of Venice, Italy	Increase
Scarton	Temporal beta-diversity	0.550	2.000	0.55	25	1990-2014	Lagoon of Venice, Italy	Increase
Scarton	Temporal beta-diversity	0.550	2.000	0.55	25	1990-2014	Lagoon of Venice, Italy	Increase
Chiron et al.	FBI	4.000	1.000	643801.00	14	2007-2020	France	Decrease
Chiron et al.	FBI	4.000	1.000	643801.00	14	2007-2020	France	Decrease
Chiron et al.	FBI	4.000	1.000	643801.00	14	2007-2020	France	Decrease
Chiron et al.	FBI	4.000	1.000	643801.00	14	2007-2020	France	Decrease

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Eglington and Pearce-Higgins	FBI	1.000	1.000	242495.00	39	1970-2008	UK	Decrease
Harrison et al. (a)	Geometric mean	10000.000	1.000	200000.00	18	1994-2011	Great Britain, UK	Stable
Harrison et al. (a)	GoF (λ = -1)	10000.000	1.000	200000.00	18	1994-2011	Great Britain, UK	Decrease
Harrison et al. (a)	GoF (λ = -2)	10000.000	1.000	200000.00	18	1994-2011	Great Britain, UK	Increase
Harrison et al. (a)	Geometric mean	62000.000	1.000	77933.00	18	1994-2011	Scotland, UK	Increase
Harrison et al. (a)	GoF (λ = -1)	62000.000	1.000	77933.00	18	1994-2011	Scotland, UK	Stable
Harrison et al. (a)	GoF (λ = -2)	62000.000	1.000	77933.00	18	1994-2011	Scotland, UK	Increase
Harrison et al. (a)	Geometric mean	16000.000	1.000	20779.00	18	1994-2011	Wales, UK	Stable
Harrison et al. (a)	GoF (λ = -1)	16000.000	1.000	20779.00	18	1994-2011	Wales, UK	Stable
Harrison et al. (a)	GoF (λ = -2)	16000.000	1.000	20779.00	18	1994-2011	Wales, UK	Stable
Harrison et al. (a)	Geometric mean	130000.000	1.000	130279.00	18	1994-2011	England, UK	Decrease

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Harrison et al. (a)	GoF (λ = -1)	130000.000	1.000	130279.00	18	1994-2011	England, UK	Decrease
Harrison et al. (a)	GoF (λ = -2)	130000.000	1.000	130279.00	18	1994-2011	England, UK	Stable
Harrison et al. (a)	Geometric mean	10000.000	1.000	200000.00	18	1994-2011	Great Britain, UK	Increase
Harrison et al. (a)	GoF (λ = -1)	10000.000	1.000	200000.00	18	1994-2011	Great Britain, UK	Stable
Harrison et al. (a)	GoF (λ = -2)	10000.000	1.000	200000.00	18	1994-2011	Great Britain, UK	Decrease
Harrison et al. (a)	Geometric mean	14000.000	1.000	77933.00	18	1994-2011	Scotland, UK	Increase
Harrison et al. (a)	GoF (λ = -1)	14000.000	1.000	77933.00	18	1994-2011	Scotland, UK	Increase
Harrison et al. (a)	GoF (λ = -2)	14000.000	1.000	77933.00	18	1994-2011	Scotland, UK	Stable
Harrison et al. (a)	Geometric mean	32300.000	1.000	130279.00	18	1994-2011	England, UK	Increase
Harrison et al. (a)	GoF (λ = -1)	32300.000	1.000	130279.00	18	1994-2011	England, UK	Decrease
Harrison et al. (a)	GoF (λ = -2)	32300.000	1.000	130279.00	18	1994-2011	England, UK	Stable

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Harrison et al. (a)	Geometric mean	3116.000	1.000	20779.00	18	1994-2011	Wales, UK	Stable
Harrison et al. (a)	GoF (λ = -1)	3116.000	1.000	20779.00	18	1994-2011	Wales, UK	Stable
Harrison et al. (a)	GoF (λ = -2)	3116.000	1.000	20779.00	18	1994-2011	Wales, UK	Increase
Juslén et al.	RLI (Red list Index)	338440.000	1.000	338440.00	10	2001-2010	Finland	Decrease
Normander et al.	BCI (Biodviersity Change Index)	84266.000	NA	1260663.00	16	1990-2005	Finland, Sweden, Norway, Denmark and Iceland	Decrease
Normander et al.	BCI (Biodviersity Change Index)	529831.000	NA	1260663.00	16	1990-2005	Finland, Sweden, Norway, Denmark and Iceland	Stable

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Normander et al.	BCI (Biodviersity Change Index)	163131.000	NA	1260663.00	16	1990-2005	Finland, Sweden, Norway, Denmark and Iceland	Decrease
Schipper et al.	Geometric mean	32.000	5.000	21792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Geometric mean	32.000	5.000	21792000.00	40	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Geometric mean	32.000	5.000	21792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Geometric mean	32.000	5.000	22792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Geometric mean	32.000	5.000	23792000.00	40	1971-2010	Canada, USA, Mexico	Stable
Schipper et al.	SR	32.000	5.000	24792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	SR	32.000	5.000	25792000.00	40	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	SR	32.000	5.000	26792000.00	40	1971-2010	Canada, USA, Mexico	Increase

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km^2)	Temporal grain (year)	Spatial extent (Km^2)	Temporal extent (year)	Years	Country	Trend
Schipper et al.	SR	32.000	5.000	27792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	SR	32.000	5.000	28792000.00	40	1971-2010	Canada, USA, Mexico	Stable
Schipper et al.	Shannon	32.000	5.000	29792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Shannon	32.000	5.000	30792000.00	40	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Shannon	32.000	5.000	31792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Shannon	32.000	5.000	32792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Shannon	32.000	5.000	33792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Simpson	32.000	5.000	34792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Simpson	32.000	5.000	35792000.00	40	1971-2010	Canada, USA, Mexico	Stable
Schipper et al.	Simpson	32.000	5.000	36792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Simpson	32.000	5.000	37792000.00	40	1971-2010	Canada, USA, Mexico	Increase

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Schipper et al.	Simpson	32.000	5.000	38792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional richness	32.000	5.000	39792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional richness	32.000	5.000	40792000.00	40	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Functional richness	32.000	5.000	41792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional richness	32.000	5.000	42792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional richness	32.000	5.000	43792000.00	40	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Functional evenness	32.000	5.000	44792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional evenness	32.000	5.000	45792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional evenness	32.000	5.000	46792000.00	40	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Functional evenness	32.000	5.000	47792000.00	40	1971-2010	Canada, USA, Mexico	Increase

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Schipper et al.	Functional evenness	32.000	5.000	48792000.00	40	1971-2010	Canada, USA, Mexico	Increase
Pilotto et al.	SR	1402.000	0.080	1402.00	27	1991-2017	Belgium	Decrease
Pilotto et al.	Simpson	1402.000	0.080	1402.00	27	1991-2017	Belgium	Increase
Pilotto et al.	Abundance	1402.000	0.080	1402.00	27	1991-2017	Belgium	Decrease
Pilotto et al.	Temporal beta-diversity	1402.000	0.080	1402.00	27	1991-2017	Belgium	Stable
Pilotto et al.	SR	509.000	1.000	509.00	42	1976-2017	Bulgaria	Increase
Pilotto et al.	Simpson	509.000	1.000	509.00	42	1976-2017	Bulgaria	Stable
Pilotto et al.	Abundance	509.000	1.000	509.00	42	1976-2017	Bulgaria	Increase
Pilotto et al.	Temporal beta-diversity	509.000	1.000	509.00	42	1976-2017	Bulgaria	Decrease
Pilotto et al.	SR	10.000	1.000	10.00	42	1976-2017	Bulgaria	Increase
Pilotto et al.	Simpson	10.000	1.000	10.00	42	1976-2017	Bulgaria	Stable
Pilotto et al.	Abundance	10.000	1.000	10.00	42	1976-2017	Bulgaria	Stable
Pilotto et al.	Temporal beta-diversity	10.000	1.000	10.00	42	1976-2017	Bulgaria	Stable
Pilotto et al.	SR	9.020	1.000	9.02	41	1977-2017	Bulgaria	Increase
Pilotto et al.	Simpson	9.020	1.000	9.02	41	1977-2017	Bulgaria	Increase
Pilotto et al.	Abundance	9.020	1.000	9.02	41	1977-2017	Bulgaria	Stable

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Pilotto et al.	Temporal beta-diversity	9.020	1.000	9.02	41	1977-2017	Bulgaria	Stable
Pilotto et al.	SR	32.000	1.000	32.00	55	1961-2015	Spain	Increase
Pilotto et al.	Simpson	32.000	1.000	32.00	55	1961-2015	Spain	Increase
Pilotto et al.	Abundance	32.000	1.000	32.00	55	1961-2015	Spain	Increase
Pilotto et al.	Temporal beta-diversity	32.000	1.000	32.00	55	1961-2015	Spain	Decrease
Pilotto et al.	SR	52000.000	1.000	52000.00	55	1961-2015	France	Stable
Pilotto et al.	Simpson	52000.000	1.000	52000.00	55	1961-2015	France	Stable
Pilotto et al.	Abundance	52000.000	1.000	52000.00	55	1961-2015	France	Stable
Pilotto et al.	Temporal beta-diversity	52000.000	1.000	52000.00	55	1961-2015	France	Stable
Pilotto et al.	SR	6155.000	0.080	6155.00	43	1975-2017	Netherlands	Increase
Pilotto et al.	Simpson	6155.000	0.080	6155.00	43	1975-2017	Netherlands	Increase
Pilotto et al.	Abundance	6155.000	0.080	6155.00	43	1975-2017	Netherlands	Increase
Pilotto et al.	Temporal beta-diversity	6155.000	0.080	6155.00	43	1975-2017	Netherlands	Stable
Pilotto et al.	SR	2180.000	1.000	2180.00	45	1974-2018	Netherlands	Decrease
Pilotto et al.	Simpson	2180.000	1.000	2180.00	45	1974-2018	Netherlands	Increase
Pilotto et al.	Abundance	2180.000	1.000	2180.00	45	1974-2018	Netherlands	Stable

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km^2)	Temporal grain (year)	Spatial extent (Km^2)	Temporal extent (year)	Years	Country	Trend
Pilotto et al.	Temporal beta-diversity	2180.000	1.000	2180.00	45	1974-2018	Netherlands	Decrease

Supplementary materials

Table 2.2: Supplementary informations on each trend

Reference	Metric	Spatial grain (Km²)	Trend	Note
Barnagaud et al.	SR	0.5	Increase	circle of radius 400 m
Barnagaud et al.	Abundance	0.5	Decrease	NA
Barnagaud et al.	Evenness	0.5	Increase	NA
Barnagaud et al.	Functional richness	0.5	Increase	NA
Barnagaud et al.	Functional dispersion	0.5	Stable	NA
Barnagaud et al.	Functional evenness	0.5	Increase	NA
Roels et al.	SR	0.04	Increase	Before/after tree planting (increase 11 times)
Roels et al.	Bird activity	0.04	Increase	Before/after tree planting (increase 3 times)
Wretenberg et al.	SR	0.03	Decrease	looking at the trend through different environmental policies, ” local species richness (i.e. at the scale of sites) decreased significantly probably as a result of an overall reduced abundance of several species. ”
Ram et al.	SR	1.6	Increase	forest species, road of 8 Km with no limitations so assumed 200m, ”species richness (the average number of species seen per route and year) ”
Ram et al.	SR	1.6	Stable	forest specialist species, road of 8 Km with no limitations so assumed 200m
Ram et al.	SR	1.6	Increase	generalist species, road of 8 Km with no limitations so assumed 200m
Ram et al.	Multi-species indicator	1.6	Increase	specialist species, road of 8 Km with no limitations so assumed 200m
Ram et al.	Multi-species indicator	1.6	Increase	generalists species, road of 8 Km with no limitations so assumed 200m
Harrison et al. (b)	Geometric mean	10000	Increase	Spatial scale = plot, ”Biodiversity as measured by the geometric mean of relative abundances has generally increased since 1994”, Visited twice a year / Increase first half and second second half

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km²)	Trend	Note
Harrison et al. (b)	GoF (λ = -1)	10000	Stable	” The goodness-of-fit-based measure of biodiversity suggests that both rare and common species made gains through much of Britain in the first half of the time period, and losses in the second half.”, Visited twice a year / Increase first half and second second half
Harrison et al. (b)	GoF (λ = -2)	10000	Stable	” The goodness-of-fit-based measure of biodiversity suggests that both rare and common species made gains through much of Britain in the first half of the time period, and losses in the second half.”, Visited twice a year / Increase first half and second second half
Doxa et al.	FBI	4	Increase	Not sure for the spatial scales, HNV +6.5%
Doxa et al.	FBI	4	Stable	Not sure for the spatial scales, for HNV +1.1%, Decrease then come back to the initial value
Doxa et al.	FBI	4	Stable	Not sure for the spatial scales, national, Decrease then come back to the initial value
Arnold et al.	SR	0.02	Stable	Non significant slight increase
Arnold et al.	Shannon	0.02	Stable	Non significant slight increase
Arnold et al.	Simpson	0.02	Stable	Non significant slight increase
Xu et al.	SR	6.56	Decrease	Urbanisation of the study area
Jiguet et al.	GBI	4	Increase	Not sure for the spatial scales, Generalist Bird Indicator, +20%
Jiguet et al.	WBI	4	Increase	Not sure for the spatial scales, Woodland Bird Indicator, -12%
Jiguet et al.	UBI	4	Increase	Not sure for the spatial scales, Urban Bird Indicator, -21%
Jiguet et al.	FBI	4	Increase	Not sure for the spatial scales, Farmland Bird Indicator, -12%
Jiguet et al.	EU bird directive	4	Increase	Not sure for the spatial scales, plus 23%
Jiguet et al.	RLI (Red list Index)	NA	Decrease	minus 75%

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km^2)	Trend	Note
Keten	SR	1.7	Stable	NA
Davey et al.	Simpson	1	Increase	NA
Davey et al.	SR	1	Increase	NA
Davey et al.	Evenness	1	Increase	NA
Christian et al.	SR	15.4	Increase	Temporal grains varies a lot,significant increase of SR
Dittrich et al.	SR	0.053	Increase	Spatial grain is the mean area of the orchards, increase sr may be due to increase in sampling effort (2 months for the first period and five for the 2nd and 3rd periods)
Dittrich et al.	SR	0.053	Increase	Spatial grain is the mean area of the orchards, increase sr may be due to increase in sampling effort (2 months for the first period and five for the 2nd and 3rd periods)
Dittrich et al.	SR	0.083	Stable	Increase until April then decrease but overall stable, spatial grain is the mean area of the orchards
Dittrich et al.	SR	0.083	Stable	Spatial grain is the mean area of the orchards
Sirami and Monadjem	SR	0.38	Decrease	NA
García-Navas et al.	Spatial beta-diversity	267	Decrease	sorensen score
Ellis et al.	SR	0.16	Stable	Riparian continuous ecosystem, area = 32 x pi x (402), spatial extent = Bear Valley of southern Grant County and Silvies Valley of northern Harney County in east-central Oregon, slight variations in sr but not exceeding se
Ellis et al.	SR	0.16	Stable	Riparian discontinuous ecosystem, area = 32 x pi x (402)
Ellis et al.	SR	0.16	Increase	Riparian herbaceous ecosystem, area = 32 x pi x (402)
Ellis et al.	SR	0.48	Stable	Riparian total ecosystem, area = 32 x pi x (402) x 3

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km^2)	Trend	Note
Ellis et al.	Shannon	0.16	Increase	Riparian continuous ecosystem, area = 32 x pi x (402), spatial extent = Bear Valley of southern Grant County and Silvies Valley of northern Harney County in east-central Oregon, slight variations in sr but not exceeding se
Ellis et al.	Shannon	0.16	Decrease	Riparian discontinuous ecosystem, slight decrease, area = 32 x pi x (402)
Ellis et al.	Shannon	0.16	Increase	Riparian herbaceous ecosystem, area = 32*pi*(402)
Ellis et al.	Shannon	0.48	Increase	Riparian total ecosystem, area = 32 x pi x (402) x 3
Ellis et al.	Simpson	0.16	Increase	Riparian continuous ecosystem, area =32 x pi x (402), spatial extent = Bear Valley of southern Grant County and Silvies Valley of northern Harney County in east-central Oregon, slight variations in sr but not exceeding se
Ellis et al.	Simpson	0.16	Decrease	Riparian discontinuous ecosystem, area = 32 x pi x (402)
Ellis et al.	Simpson	0.16	Increase	Riparian herbaceous ecosystem, area = 32 x pi x (402)
Ellis et al.	Simpson	0.48	Decrease	Riparian total ecosystem, slight decrease, area = 32 x pi x (402) x 3
Sicurella et al.	Occurence (%)	17370.3	Stable	NPA non protected area, not sure for the spatial scale
Sicurella et al.	Occurence (%)	1403.9	Stable	NR nature reserves, not sure for the spatial scale
Sicurella et al.	Occurence (%)	6461.9	Increase	RP regional parks, not sure for the spatial scale
Nally	SR	0.49	Increase	Temporal grain = 1 day
Latta et al.	SR	1.18	Decrease	54 to 31 species, untouched forest, from Hill and Hamer ”assuming a 250-m sampling radius for mist nets”, ”In each habitat, we sampled birds with 20 mist nets” so area = (pi x 250^2) x 6 m^2
Latta et al.	SR	1.18	Decrease	67 to 30 species, introduced tree species in the forest
Scarton	SR	0.55	Increase	14 to 25 species
Scarton	Shannon	0.55	Increase	2.07 to 2.38
Scarton	Temporal beta-diversity	0.55	Increase	2.07 to 2.38

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km²)	Trend	Note
Scarton	Temporal beta-diversity	0.55	Increase	2.07 to 2.38
Chiron et al.	FBI	4	Decrease	Concerning the spatial scale, predictions are made using the spatial unit of 4 Km², Prediction with baseline scenario
Chiron et al.	FBI	4	Decrease	Prediction with CAP greening cenario
Chiron et al.	FBI	4	Decrease	Prediction with No Pillar I scenario
Chiron et al.	FBI	4	Decrease	Prediction with biofuel scenario
Eglington and Pearce-Higgins	FBI	1	Decrease	From 1 to 0.5
Harrison et al. (a)	Geometric mean	10000	Stable	Farmland communities
Harrison et al. (a)	GoF (λ = -1)	10000	Decrease	Farmland communities, GoF weighted towards the rare species
Harrison et al. (a)	GoF (λ = -2)	10000	Increase	Farmland communities, GoF weighted towards the common species
Harrison et al. (a)	Geometric mean	62000	Increase	Farmland communities
Harrison et al. (a)	GoF (λ = -1)	62000	Stable	Farmland communities, GoF weighted towards the rare species
Harrison et al. (a)	GoF (λ = -2)	62000	Increase	Farmland communities, GoF weighted towards the common species
Harrison et al. (a)	Geometric mean	16000	Stable	Farmland communities
Harrison et al. (a)	GoF (λ = -1)	16000	Stable	Farmland communities, GoF weighted towards the rare species
Harrison et al. (a)	GoF (λ = -2)	16000	Stable	Farmland communities, GoF weighted towards the common species
Harrison et al. (a)	Geometric mean	130000	Decrease	Farmland communities
Harrison et al. (a)	GoF (λ = -1)	130000	Decrease	Farmland communities, GoF weighted towards the rare species
Harrison et al. (a)	GoF (λ = -2)	130000	Stable	Farmland communities, GoF weighted towards the common species
Harrison et al. (a)	Geometric mean	10000	Increase	Woodland communities, supplemtary material
Harrison et al. (a)	GoF (λ = -1)	10000	Stable	Woodland communities, supplemtary material
Harrison et al. (a)	GoF (λ = -2)	10000	Decrease	Woodland communities, supplemtary material
Harrison et al. (a)	Geometric mean	14000	Increase	Woodland communities

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km^2)	Trend	Note
Harrison et al. (a)	GoF (λ = -1)	14000	Increase	Woodland communities
Harrison et al. (a)	GoF (λ = -2)	14000	Stable	not sure for the trend, Woodland communities
Harrison et al. (a)	Geometric mean	32300	Increase	Woodland communities
Harrison et al. (a)	GoF (λ = -1)	32300	Decrease	Not sure for the trend, Woodland communities
Harrison et al. (a)	GoF (λ = -2)	32300	Stable	Not sure for the trend, Woodland communities
Harrison et al. (a)	Geometric mean	3116	Stable	Not sure for the trend, Woodland communities
Harrison et al. (a)	GoF (λ = -1)	3116	Stable	Not sure for the trend, Woodland communities
Harrison et al. (a)	GoF (λ = -2)	3116	Increase	Not sure for the trend, Woodland communities
Juslén et al.	RLI (Red list Index)	338440	Decrease	NA
Normander et al.	BCI (Biodviersity Change Index)	84266	Decrease	Farmland
Normander et al.	BCI (Biodviersity Change Index)	529831	Stable	Forest
Normander et al.	BCI (Biodviersity Change Index)	163131	Decrease	Mires
Schipper et al.	Geometric mean	32	Increase	All
Schipper et al.	Geometric mean	32	Decrease	Grassland
Schipper et al.	Geometric mean	32	Increase	Woodland
Schipper et al.	Geometric mean	32	Increase	Wetland
Schipper et al.	Geometric mean	32	Stable	Shrubland
Schipper et al.	SR	32	Increase	All
Schipper et al.	SR	32	Decrease	Grassland
Schipper et al.	SR	32	Increase	Woodland
Schipper et al.	SR	32	Increase	Wetland
Schipper et al.	SR	32	Stable	Shrubland
Schipper et al.	Shannon	32	Increase	All

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km²)	Trend	Note
Schipper et al.	Shannon	32	Decrease	Grassland
Schipper et al.	Shannon	32	Increase	Woodland
Schipper et al.	Shannon	32	Increase	Wetland
Schipper et al.	Shannon	32	Increase	Shrubland
Schipper et al.	Simpson	32	Increase	All
Schipper et al.	Simpson	32	Stable	Grassland
Schipper et al.	Simpson	32	Increase	Woodland
Schipper et al.	Simpson	32	Increase	Wetland
Schipper et al.	Simpson	32	Increase	Shrubland
Schipper et al.	Functional richness	32	Increase	All
Schipper et al.	Functional richness	32	Decrease	Grassland
Schipper et al.	Functional richness	32	Increase	Woodland
Schipper et al.	Functional richness	32	Increase	Wetland
Schipper et al.	Functional richness	32	Decrease	Shrubland
Schipper et al.	Functional evenness	32	Increase	All
Schipper et al.	Functional evenness	32	Increase	Grassland
Schipper et al.	Functional evenness	32	Decrease	Woodland
Schipper et al.	Functional evenness	32	Increase	Wetland
Schipper et al.	Functional evenness	32	Increase	Shrubland
Pilotto et al.	SR	1402	Decrease	Dataset S004, temporal grain = 1 month
Pilotto et al.	Simpson	1402	Increase	Dataset S004, temporal grain = 1 month
Pilotto et al.	Abundance	1402	Decrease	Dataset S004, temporal grain = 1 month
Pilotto et al.	Temporal beta-diversity	1402	Stable	Dataset S004, temporal grain = 1 month, p-val = 0.8

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km²)	Trend	Note
Pilotto et al.	SR	509	Increase	Dataset S011
Pilotto et al.	Simpson	509	Stable	Dataset S011, p-val = 0.8
Pilotto et al.	Abundance	509	Increase	Dataset S011
Pilotto et al.	Temporal beta-diversity	509	Decrease	Dataset S011
Pilotto et al.	SR	10	Increase	Dataset S012
Pilotto et al.	Simpson	10	Stable	Dataset S012, p-val = 0.1
Pilotto et al.	Abundance	10	Stable	Dataset S012, p-val = 0.22
Pilotto et al.	Temporal beta-diversity	10	Stable	Dataset S012, p-val = 0.9
Pilotto et al.	SR	9.02	Increase	Dataset S013
Pilotto et al.	Simpson	9.02	Increase	Dataset S013
Pilotto et al.	Abundance	9.02	Stable	Dataset S013
Pilotto et al.	Temporal beta-diversity	9.02	Stable	Dataset S013
Pilotto et al.	SR	32	Increase	Dataset S047
Pilotto et al.	Simpson	32	Increase	Dataset S047
Pilotto et al.	Abundance	32	Increase	Dataset S047
Pilotto et al.	Temporal beta-diversity	32	Decrease	Dataset S047
Pilotto et al.	SR	52000	Stable	Dataset S076
Pilotto et al.	Simpson	52000	Stable	Dataset S076
Pilotto et al.	Abundance	52000	Stable	Dataset S076
Pilotto et al.	Temporal beta-diversity	52000	Stable	Dataset S076
Pilotto et al.	SR	6155	Increase	Dataset S094
Pilotto et al.	Simpson	6155	Increase	Dataset S094
Pilotto et al.	Abundance	6155	Increase	Dataset S094

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km²)	Trend	Note
Pilotto et al.	Temporal beta-diversity	6155	Stable	Dataset S094
Pilotto et al.	SR	2180	Decrease	Dataset S095
Pilotto et al.	Simpson	2180	Increase	Dataset S095
Pilotto et al.	Abundance	2180	Stable	Dataset S095, p-val = 0.056
Pilotto et al.	Temporal beta-diversity	2180	Decrease	Dataset S095

References

Arnold, H., Deacon, A. E., Hulme, M. F., Sansom, A., Jaggernauth, D., and Magurran, A. E. Contrasting trends in biodiversity of birds and trees during succession following cacao agroforest abandonment. 58(6):1248–1260. _eprint: https://besjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/1365-2664.13869.

Barnagaud, J.-Y., Gaüzère, P., Zuckerberg, B., Princé, K., and Svenning, J.-C. Temporal changes in bird functional diversity across the united states. 185(4):737–748.

Barnosky, A. D., Matzke, N., Tomiya, S., Wogan, G. O. U., Swartz, B., Quental, T. B., Marshall, C., McGuire, J. L., Lindsey, E. L., Maguire, K. C., Mersey, B., and Ferrer, E. A. Has the earth's sixth mass extinction already arrived? 471(7336):51–57. Number: 7336 Publisher: Nature Publishing Group.

Bejček, V. and Stastný. Velké ptačí mapování.

Blowes, S. A., Supp, S. R., Antão, L. H., Bates, A., Bruelheide, H., Chase, J. M., Moyes, F., Magurran, A., McGill, B., Myers-Smith, I. H., Winter, M., Bjorkman, A. D., Bowler, D. E., Byrnes, J. E. K., Gonzalez, A., Hines, J., Isbell, F., Jones, H. P., Navarro, L. M., Thompson, P. L., Vellend, M., Waldock, C., and Dornelas, M. The geography of biodiversity change in marine and terrestrial assemblages. 366(6463):339–345. Publisher: American Association for the Advancement of Science Section: Research Article.

Butchart, S., Stattersfield, A., Baillie, J., Bennun, L., Stuart, S., Akçakaya, H., Hilton-Taylor, C., and Mace, G. Using red list indices to measure progress towards the 2010 target and beyond. 360(1454):255–268. Publisher: Royal Society.

Butchart, S. H. M., Akçakaya, H. R., Chanson, J., Baillie, J. E. M., Collen, B., Quader, S., Turner, W. R., Amin, R., Stuart, S. N., and Hilton-Taylor, C. Improvements to the red list index. 2(1):e140. Publisher: Public Library of Science.

Butchart, S. H. M., Stattersfield, A. J., Bennun, L. A., Shutes, S. M., Akçakaya, H. R., Baillie, J. E. M., Stuart, S. N., Hilton-Taylor, C., and Mace, G. M. Measuring global trends in the status of biodiversity: Red list indices for birds. 2(12):e383.

Chase, J. M., McGill, B. J., Thompson, P. L., Antão, L. H., Bates, A. E., Blowes, S. A., Dornelas, M., Gonzalez, A., Magurran, A. E., Supp, S. R., Winter, M., Bjorkman, A. D., Bruelheide, H., Byrnes, J. E. K., Cabral, J. S., Elahi, R., Gomez, C., Guzman, H. M., Isbell, F., Myers-Smith, I. H., Jones, H. P., Hines, J., Vellend, M., Waldock, C., and O'Connor, M. Species richness change across spatial scales. 128(8):1079–1091.

Chiron, F., Princé, K., Paracchini, M. L., Bulgheroni, C., and Jiguet, F. Forecasting the potential impacts of CAP-associated land use changes on farmland birds at the national level. 176:17–23.

Christian, K., Isabelle, L. V., Frédéric, J., and Vincent, D. More species, fewer specialists: 100 years of changes in community composition in an island biogeographical study. 15(4):641–648. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1472-4642.2009.00569.x.

Davey, C. M., Chamberlain, D. E., Newson, S. E., Noble, D. G., and Johnston, A. Rise of the generalists: evidence for climate driven homogenization in avian communities. 21(5):568–578. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1466-8238.2011.00693.x.

Dittrich, R., Giessing, B., Benito, M. M., Russ, A., Wolf, C., Foudoulakis, M., and Norman, S. Multiyear monitoring of bird communities in chlorpyrifos-treated orchards in spain and the united kingdom: Spatial and temporal trends in species composition, abundance, and site fidelity. 38(3):616–629. _eprint: https://setac.onlinelibrary.wiley.com/doi/pdf/10.1002/etc.4317.

Dornelas, M., Magurran, A. E., Buckland, S. T., Chao, A., Chazdon, R. L., Colwell, R. K., Curtis, T., Gaston, K. J., Gotelli, N. J., Kosnik, M. A., McGill, B., McCune, J. L., Morlon, H., Mumby, P. J., Øvreås, L., Studeny, A., and Vellend, M. Quantifying temporal change in biodiversity: challenges and opportunities. 280(1750):20121931.

Doxa, A., Bas, Y., Paracchini, M. L., Pointereau, P., Terres, J.-M., and Jiguet, F. Low-intensity agriculture increases farmland bird abundances in france. 47(6):1348–1356. _eprint: https://besjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2664.2010.01869.x.

Eglington, S. M. and Pearce-Higgins, J. W. Disentangling the relative importance of changes in climate and land-use intensity in driving recent bird population trends. 7(3):e30407.

Ellis, M. S., Kennedy, P. L., Edge, W. D., and Sanders, T. A. Twenty-year changes in riparian bird communities of east-central oregon. 131(1):43–61. Publisher: The Wilson Ornithological Society.

García-Navas, V., Sattler, T., Schmid, H., and Ozgul, A. Temporal homogenization of functional and beta diversity in bird communities of the swiss alps. 26(8):900–911. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/ddi.13076.

Gregory, R. D. and Strien, A. v. Wild bird indicators: using composite population trends of birds as measures of environmental health. 9(1):3–22.

Gregory, R. D., van Strien, A., Vorisek, P., Gmelig Meyling, A. W., Noble, D. G., Foppen, R. P., and Gibbons, D. W. Developing indicators for european birds. 360(1454):269–288. Publisher: Royal Society.

Gregory, R. D., Vorisek, P., Strien, A. V., Meyling, A. W. G., Jiguet, F., Fornasari, L., Reif, J., Chylarecki, P., and Burfield, I. J. Population trends of widespread woodland birds in europe. 149:78–97. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1474-919X.2007.00698.x.

Harrison, P. J., Buckland, S. T., Yuan, Y., Elston, D. A., Brewer, M. J., Johnston, A., and Pearce-Higgins, J. W. Assessing trends in biodiversity over space and time using the example of british breeding birds. 51(6):1650–1660. _eprint: https://besjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/1365-2664.12316.

Harrison, P. J., Yuan, Y., Buckland, S. T., Oedekoven, C. S., Elston, D. A., Brewer, M. J., Johnston, A., and Pearce-Higgins, J. W. Quantifying turnover in biodiversity of british breeding birds. 53(2):469–478. _eprint: https://besjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/1365-2664.12539.

Hill, J. K. and Hamer, K. C. Determining impacts of habitat modification on diversity of tropical forest fauna: the importance of spatial scale. 41(4):744–754. _eprint: https://besjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/j.0021-8901.2004.00926.x.

Hill, M. O. Diversity and evenness: A unifying notation and its consequences. 54(2):427–432. _eprint: https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.2307/1934352.

Jaccard, P. The distribution of the flora in the alpine zone.1. 11(2):37–50. _eprint: https://nph.onlinelibrary.wiley.com/doi/pdf/10.1111/j.1469-8137.1912.tb05611.x.

Jiguet, F., Devictor, V., Julliard, R., and Couvet, D. French citizens monitoring ordinary birds provide tools for conservation and ecological sciences. 44:58–66.

Juslén, A., Hyvärinen, E., and Virtanen, L. K. Application of the red-list index at a national level for multiple species groups. 27(2):398–406. _eprint: https://conbio.onlinelibrary.wiley.com/doi/pdf/10.1111/cobi.12016.

Keil, P., Schweiger, O., Kühn, I., Kunin, W. E., Kuussaari, M., Settele, J., Henle, K., Brotons, L., Pe'er, G., Lengyel, S., Moustakas, A., Steinicke, H., and Storch, D. Patterns of beta diversity in europe: the role of climate, land cover and distance across scales. 39(8):1473–1486. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2699.2012.02701.x.

Keten. Temporal patterns of wetland-associated bird assemblages in altered wetlands in turkey.

Latta, S. C., Tinoco, B. A., Astudillo, P. X., and Graham, C. H. Patterns and magnitude of temporal change in avian communities in the ecuadorian andes. 113(1):24–40.

Nally, R. M. Monitoring forest bird communities for impact assessment: The influence of sampling intensity and spatial scale. 82(3):355–367.

Normander, B., Levin, G., Auvinen, A.-P., Bratli, H., Stabbetorp, O., Hedblom, M., Glimskär, A., and Gudmundsson, G. A. Indicator framework for measuring quantity and quality of biodiversity—exemplified in the nordic countries. 13(1):104–116.

Pereira, H. M., Navarro, L. M., and Martins, I. S. Global biodiversity change: The bad, the good, and the unknown. 37(1):25–50.

Pilotto, F., Kühn, I., Adrian, R., Alber, R., Alignier, A., Andrews, C., Bäck, J., Barbaro, L., Beaumont, D., Beenaerts, N., Benham, S., Boukal, D. S., Bretagnolle, V., Camatti, E., Canullo, R., Cardoso, P. G., Ens, B. J., Everaert, G., Evtimova, V., Feuchtmayr, H., García-González, R., Gómez García, D., Grandin, U., Gutowski, J. M., Hadar, L., Halada, L., Halassy, M., Hummel, H., Huttunen, K.-L., Jaroszewicz, B., Jensen, T. C., Kalivoda, H., Schmidt, I. K., Kröncke, I., Leinonen, R., Martinho, F., Meesenburg, H., Meyer, J., Minerbi, S., Monteith, D., Nikolov, B. P., Oro, D., Ozoliņš, D., Padedda, B. M., Pallett, D., Pansera, M., Pardal, M. n., Petriccione, B., Pipan, T., Pöyry, J., Schäfer, S. M., Schaub, M., Schneider, S. C., Skuja, A., Soetaert, K., Spriņģe, G., Stanchev, R., Stockan, J. A., Stoll, S., Sundqvist, L., Thimonier, A., Van Hoey, G., Van Ryckegem, G., Visser, M. E., Vorhauser, S., and Haase, P. Meta-analysis of multidecadal biodiversity trends in europe. 11(1):3486. Bandiera_abtest: a Cc_license_type: cc_by Cg_type: Nature Research Journals Number: 1 Primary_atype: Research Publisher: Nature Publishing Group Subject_term: Biodiversity;Climate-change ecology;Macroecology Subject_term_id: biodiversity;climate-change-ecology;macroecology.

Ram, D., Axelsson, A.-L., Green, M., Smith, H. G., and Lindström, k. What drives current population trends in forest birds – forest quantity, quality or climate? a large-scale analysis from northern europe. 385:177–188.

Roels, S., Hannay, M., and Lindell, C. Recovery of bird activity and species richness in an early-stage tropical forest restoration. 14(1). Publisher: The Resilience Alliance.

Scarton, F. Long-term trend of the waterbird community breeding in a heavily man-modified coastal lagoon: the case of the important bird area "lagoon of venice". 21(1):35–45.

Schipper, A. M., Belmaker, J., Miranda, M. D. d., Navarro, L. M., Böhning-Gaese, K., Costello, M. J., Dornelas, M., Foppen, R., Hortal, J., Huijbregts, M. A. J., Martín-López, B., Pettorelli, N., Queiroz, C., Rossberg, A. G., Santini, L., Schiffers, K., Steinmann, Z. J. N., Visconti, P., Rondinini, C., and Pereira, H. M. Contrasting changes in the abundance and diversity of north american bird assemblages from 1971 to 2010. 22(12):3948–3959. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/gcb.13292.

Shannon, C. E. A mathematical theory of communication. 27(3):379–423. Conference Name: The Bell System Technical Journal.

Sicurella, B., Orioli, V., Pinoli, G., Ambrosini, R., and Bani, L. Effectiveness of the system of protected areas of lombardy (northern italy) in preserving breeding birds. 28(3):475–492. Publisher: Cambridge University Press.

Simpson, E. H. Measurement of diversity. 163(4148):688–688. Bandiera_abtest: a Cg_type: Nature Research Journals Number: 4148 Primary_atype: Research Publisher: Nature Publishing Group.

Sirami, C. and Monadjem, A. Changes in bird communities in swaziland savannas between 1998 and 2008 owing to shrub encroachment. 18(4):390–400. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1472-4642.2011.00810.x.

Sørensen, T. J. *A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons.* I kommission hos E. Munksgaard. OCLC: 4713331.

Studeny, A. C., Buckland, S. T., Illian, J. B., Johnston, A., and Magurran, A. E. Goodness of fit measures of evenness: a new tool for exploring changes in community structure. 2(2):art15. _eprint: https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1890/ES10-00074.1.

The Convention on Biological Diversity, B. The convention on biological diversity. Publisher: Secretariat of the Convention on Biological Diversity.

Whittaker, R. H. Evolution and measurement of species diversity. 21(2):213–251. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.2307/1218190.

Whittaker, R. H. Vegetation of the siskiyou mountains, oregon and california. 30(3):279–338. _eprint: https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.2307/1943563.

Wretenberg, J., Pärt, T., and Berg, k. Changes in local species richness of farmland birds in relation to land-use changes and landscape structure. 143(2):375–381.

Xu, X., Xie, Y., Qi, K., Luo, Z., and Wang, X. Detecting the response of bird communities and biodiversity to habitat loss and fragmentation due to urbanization. 624:1561–1576.